THE INTELLECTUAL OBSERVER.

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EGG FUNGI.

BY THE REV. M. J. BERKELEY, M.A., F.L.S.

(*With a Coloured and Tinted Plate.*)

A DRAWING of a beautiful fungus was lately forwarded to the editor of the INTELLECTUAL OBSERVER, which was gathered in dark rich soil at Riverstone, on the Clarence river, Australia, with the information that its charming form and colouring were hardly sufficient compensation for its detestable odour. This latter attribute is characteristic of the whole group to which it belongs, and which is illustrated here on account of the very curious and striking characters which the species frequently present, so that they are always objects of interest to travellers, insomuch that, while other fungi are neglected, drawings of these are often sent home; though good specimens are rare in herbaria, as, from their soft and partially gelatinous consistence, they do not preserve their distinctive character well when dry.

Many of the finest forms occur in countries where the temperature, during at least a portion of the year, is high; but we are not without examples in our own country, one out of three species which belong to our mycological list (*Clathrus cancellatus*) being most conspicuous from its bright coral red net-work, springing out of a white gelatinous volva. This, however, is one of our rarer fungi, and occurs only in the southern parts of our island, though it is not uncommon in southern Europe. Beautiful, however, as it is, the odour is not less offensive than that of the common stinkhorn (*Phallus impudicus*), which is abundant in many parts of Great Britain, extending as far north as Aberdeenshire, where I have seen it in great perfection. The shrubberies at Kew are at certain seasons of the year infested by it, so as to make it disagreeable to walk in them, scores of specimens often occurring within a circle of a few yards. A single specimen, indeed, is quite

enough to taint the air for a great distance, and, in consequence, a letter was last autumn sent to the *Times* newspaper from Surrey, gravely asking whether it might not be the cause of a prevalent epidemic. Disgusting, however, as the fructifying mass is which drips down from the plant when mature, it is a favourite food of flies, which devour it greedily. A variety occurs on the eastern coast, which has been figured by Curtis in his genera of British insects, under the name of *Phallus iosmos*, which is said to have the scent of violets; but this is so contrary to the general nature of these fungi, that the matter certainly requires confirmation. The observation that if one has courage enough to hold the stink-horn near enough, the odour loses much of its character, is not confirmed by my own observations.

It would, however, be hardly fair upon those mal-odoriferous fungi to give them so bad a character, without pointing to the fact that there are other fungi which far exceed them in this offensive quality. *Thelephora fastidiosa* is, to my apprehension, still more disgusting; and there is a white Corticium which grows on sawdust which is equally obnoxious; but assuredly the worst I have ever met with is *Thelephora fœtida*, which I have gathered only in fir woods in Aberdeenshire. When first observed, there is nothing very peculiar in the scent, but after being enclosed for a few minutes in the vasculum, it is almost insupportable. I shall not easily forget my horror, when, in going up to my room where I had deposited my specimens, there was the most odious scent, as if it contained a putrid corpse. I have no doubt that if I had been at an inn, I should have been coolly requested to change my quarters, if a policeman had not come with a search-warrant, to see if I had not committed some dreadful crime. I was unwilling, however, to lose my specimens, and found that, till I had enfolded them in twelve wrappers of thick paper, they did not cease to bewray their presence.

It is time, however, to take a more æsthetic view of these vegetables; for it will be seen from the illustrations which accompany this notice, that they are most attractive to the eye, if not to another sense.

In all the species, the part which bears the fructification is inclosed, when young, in an egg-like body, consisting of at least three strata, the inner one of which is thick and gelatinous, from which circumstance I have termed them Egg Fungi. This volva, or wrapper, bursts either irregularly, or splits into several lobes. In some instances, the fructifying part, in acquiring its full development, increases so rapidly, or the lacunæ with which it abounds change their dimensions so suddenly, being at first much compressed from being packed in a

very small space, that the volva opens with a loud report, or bursts any fragile body within which it may be confined. In New Zealand, where everything that can possibly be eaten is an object of research, the volva of species of *Ileodictyon* (Fig. 9), and possibly the receptacle also, when free from the fructifying mass, is consumed by the natives, by whom it is known by a name equivalent to thunder-dirt (*Paru watitiri*); but whether, from something of the same notion from which in our own country the gelatinous masses, so common on our gravel walks after rain, belonging to the genus *Nostoc*, are termed fallen stars, or because, like many other fungi, the Ileodictya are most common after thunder storms, I am unable to say. A Lysurus (*L. Mokusin*), of which genus a species is given in the tinted plate (Fig. 10), is employed by the Chinese as a remedy for cancerous ulcers. Beyond this, I am not aware of any use to which the egg fungi are applied. Amongst the puffballs, there is a very curious genus, *Battarea*, which has a peridium seated on a very long stalk, which is at first inclosed in a very similar volva, and on a small scale, the curious genus *Sphærobolus*, which was illustrated in the Intellectual Observer, Vol. vi., p. 252, presents a volva which affords certain points of comparison. These are the only instances, apart from the egg fungi, where there is, as far as I recollect, a similar structure.

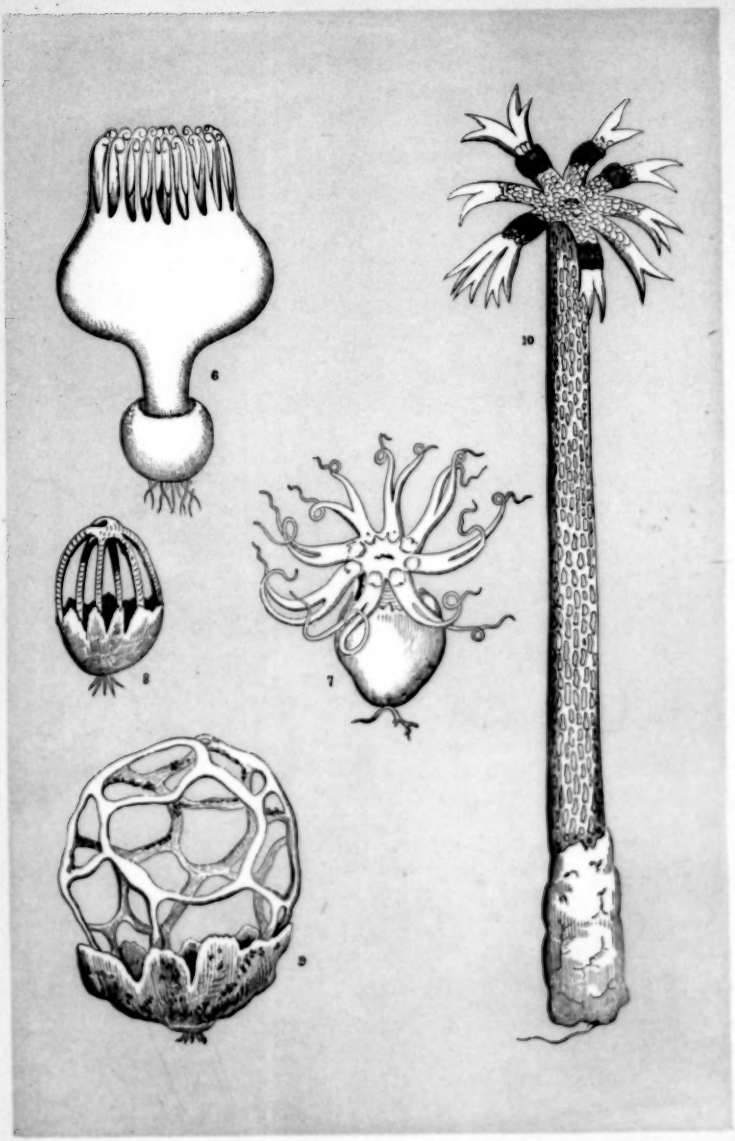
The species may be divided conveniently into four groups, in the first of which, the sessile receptacle, is either decidedly reticulate, or consists of a few columns united above (Figs. 5, 8, 9); in the second, it forms a reticulated body, surmounting a stem of greater or less height (Fig. 2); in the third, it consists of a stipitate cap (Figs. 3, 4); while in a fourth, it is divided into a number of radiating lobes, and is either more or less sessile, or decidedly stipitate. (Figs. 1, 6, 7, 10.)

The genus *Clathrus* (Figs. 5, 8) occurs in various parts of the world, but not in high northern latitudes. In the more typical species, the receptacle is reticulate throughout, but in others it is reticulate at the base only, as in *Clathrus pusillus* (Fig. 8), while in one or two species the receptacle is merely columnar. In all, it is more or less lacunose, while in a few it is beautifully crisped or puckered, as in *Clathrus crispus*. It is uncertain whether *Clathrus triscapus*, or, as it is sometimes called, *Laternea triscapa*, is divisible into two or more species. One (Fig. 5) taken from a drawing made in Java has the columns bisulcate within, and deeply puckered, while in one, of which I have a coloured figure on rice paper, from the West Indies, they appear to be even. A careful examination of fresh or well-dried specimens is requisite to determine the point accurately. A closely allied species, referred to a distinct genus *Colus*,

which is, however, scarcely distinct, occurs in southern Europe. *Ileodictyon* is separated from *Clathrus* on account of the branches of the receptacle being hollow and free from lacunæ. In all, the hymenium is situated on the inner side of the receptacle, and consists at first of a delicate, highly sinuated mass, which bears a number of naked spores on sporophores, as in the higher fungi. As soon as these are well developed, the membranous walls are decomposed, and by the time the volva bursts, the whole forms an olive coloured, semifluid body, which either falls away in drops, or is carried off by insects.

In the second group, which consists of the genus *Simblum*, the structure is much like that of *Clathrus*, only the reticulate receptacle is elevated on a tall stem. Three species are at present known; one, on which the genus was founded, from Mauritius; the second from Ceylon, and the very beautiful species here figured (Fig. 2), *Simblum flavescens*, Kurtz, which occurs on the trunks of bamboos, and near the cottages of the natives, in the rainy season, during the months of April, May, and June, in Java. It is mostly solitary, with an ovate, obtuse head, confluent with the pale sulphur-coloured hollow stem; the reticulations are at first hexagonal, and are filled up with the olive hymenium; this, however, soon vanishes, and leaves the meshes distinct; the stem is elastic and spongy; the volva globose, and bursts irregularly. The sides of the reticulations are elegantly sinuated.

In the third group the head is undivided, perfectly distinct from, or confluent with, the stem; even, undulated or deeply pitted, and either pierced at the apex with a pore which communicates with the hollow of the stem, or quite imperforate. To the former group belongs the beautiful genus *Dictyophora* (Fig. 6), which is apparently confined to tropical or subtropical countries. The head is seated on the top of the stem like a pileus, being perfectly free beneath, and between it and the stem hangs down a delicate reticulated appendage of considerable length and width, the meshes of which are either smooth or striated, the whole being, as if to prove that there is nothing new under the sun, an anticipation of the favourite crinoline. The species at present are very imperfectly known, as their characters are not well preserved in dried specimens. That figured here grows on trunks of bamboos in Java, and appears to be *Dictyophora phalloidea*, Lév. (Fig. 4.) In the specimen figured, the network is white, but a variety occurs in which it is of a beautiful saffron. Two other species occur in Java on bamboo, or on rich soil, one of which, collected by Zöllinger, and supposed to be the true *Phallus Dæmonum* of Rumph, has the cap deeply pitted, and the network crenulate and of a delicate yellow; in the other, *Dictyophora merulina*,



EGG FUNGI.

(Plate II.)

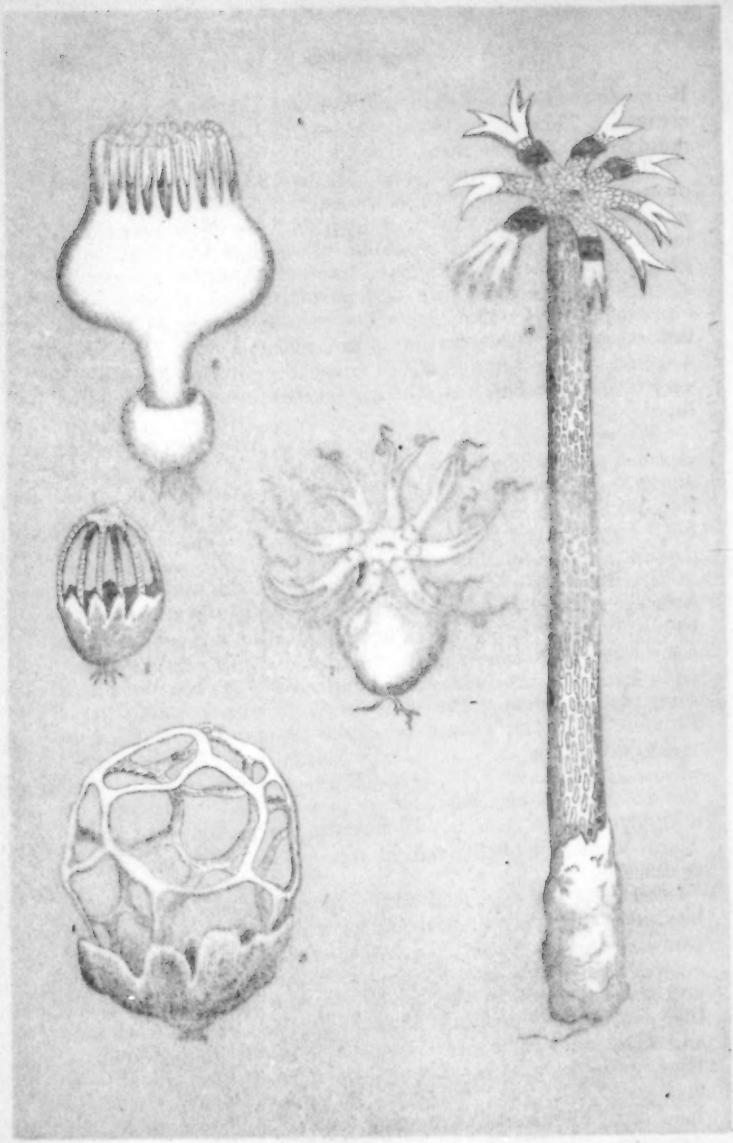
6.—Calathiscus sepia, Mont.
7.—Aserče viridis, Berk. and Hook, fil.
8.—Clathrus pusillus, Berk.
9.—Ilcodictyon gracile, Berk.
10.—Lysurus aserčeformis, Corda.

Berk., the reticulations are gill-like, and the ochraceous head rivulose. This occurs at all seasons, and appears to be the more frequent of the three.

The curious fungus (Fig. 3), figured from a beautiful drawing by Kurtz, belongs to the imperforate set. It is *Cynophallus bambusinus*, Zöllinger, and, like the *Dictyophoræ* just mentioned, grows on the trunks of bamboo in Java. It is gregarious, with an elongated conical subacute receptacle, strongly papillose, and of a deep purple red; the stem is fistulose and rose coloured, the volva white. The head is sometimes crowned with a portion of the ruptured volva. We have a species of the same genus in Great Britain, but it is not of very common occurrence, though one of our most interesting fungi.

We now come to the fourth group, in which the receptacle is more or less deeply divided, the divisions being distinct above and not united, as in the columnar Clathri, with which they are closely connected. *Lysurus Archeri*, Berk., beautifully figured in the botany of the antarctic voyage, is quite destitute of a stem, and differs mainly from *Clathrus triscapus* in the divisions not being united above. Its close affinity, however, with *Aseröe*, to be noticed presently, is indicated by the tip being very shortly bifid, though the divisions do not seem to separate readily from each other. In other species, as in *Lysurus mokusin* and *L. aserōiformis* (Fig. 10), there is a long distinct stem. The volva of the former is eaten by the Chinese, but when putrid, poisonous; and when calcined, as mentioned above, the powder is applied to gangrenous ulcers. In *Lysurus aserōiformis* (Fig. 10), as the name implies, the divisions of the receptacle are so deep, that it is essentially a highly stipitate Aseröe. It was found by Sieber in Australia. The receptacle is of a beautiful rose colour, inclining in parts to carmine.

Aseröe is distinguished from typical Lysuri by the deeply bifid rays of the receptacle. *Aseröe rubra* (Fig. 1) appears to assume a great number of forms. I had the advantage of comparing numerous specimens with the late Mr. R. Brown, and we both came to the conclusion, that *A. pentactina*, and the very different looking plant as figured by Labillardiere, and which once came up in some soil from New Holland, at Kew, were in reality the same species. *A. rubra* (Fig. 1) is a most elegant fungus. "The pileus," after a description by M. Leichardt, by whom the drawing copied in our coloured plate was made, "is divided into eight rays, each of which is forked, the divisions being acuminated and slightly twisted. The centre of this pileus is perforated by a rather large irregular aperture, by means of which there is a communication with



ZOO FUNGI

(Plate II.)

6.—Calathiscus sepia, Mont.
7.—Aserõe viridis, Berk. and Hook. fil.
8.—Clathrus pusillus, Berk.
9.—Clathrulus gracile, Berk.
10.—Lysurus mesenteriformis, Corda.

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the cavity of the stipes and the atmosphere. A dark brownish moist matter covers the upper surface of the disc. The rays are of a fine bright scarlet above, while the under surface and stem are of a pale rose colour. An attentive observation with a lens exhibits minute openings, one at the base of each ray, which communicates with larger holes immediately beneath the upper layer of the disc.

The other species figured *Aserŏe Hookeri*, Berk. (Fig. 7), was originally found by Dr. Hooker on clay banks or hills near the Bay of Islands, New Zealand. It differs essentially in the transversely wrinkled stem; and the mode in which the half rays of each pair are connected with each other, calling to mind the arrangement in the column of *Asclepiadiæ*. The rays are strongly grooved beneath, and perfectly distinct from the stem. Two forms are found, the one which we owe to Mr. Colenso, of a more or less deep red, the other of a metallic green.

An *Aserŏe* occurs in Ceylon in which the rays seem to be more irregular, paving the way for Dr. Montagne's genus *Calathiscus*, in which all the rays are equal. *Calathiscus sepia*, Mont. (Fig. 6), was found near Ootacamund in Western Hindostan, near the roots of trees in moist woods in rainy weather in September. The stem is about two inches high, and confluent with the receptacle, which is dilated so as to present the form of a calathus. The margin is divided half-way into about twenty equal divisions, which are greatly attenuated and curled inwards at the top; the volva is globular and white, the rest of the fungus pale pink, with the exception of a narrow ring which surrounds the open top of the stem, which is the hymenium.

Several other genera might have been added, but enough are given to show the general character of a highly interesting group.

The Figures represent—1. *Aserŏe rubra*, half natural size; 2. *Simblum flavescens*, one-third natural size; 3. *Cynophallus bambusinus*, half natural size; 4. *Dictyophora phalloidea*, half natural size; 5. *Clathrus triscapus*, half natural size; 6. *Calathiscus sepia*, three-eighths natural size; 7. *Aserŏe Hookeri*, half natural size; 8. *Clathrus pusillus*, half natural size; 9. *Ileodictyon gracile*, three-fourths natural size (*Ileodictyon cibarium*, the New Zealand species, is much larger); 10. *Lysurus aserŏiformis*, two-thirds natural size.

ON THE APPLICATION OF SCIENTIFIC DISCOVERY TO THE USEFUL ARTS.

No. II.

BY PROFESSOR M'GAULEY.

In a recent paper I endeavoured to recall to the mind of the reader some important applications of science, having reference especially to a saving of labour. I shall now direct attention rather to the effect of scientific discovery in the prevention of injury to health, or of pecuniary loss from unnecessary waste, and in the production of new and valuable materials. On this, as on the former occasion, only a few examples can be selected from the many which testify to the advantages conferred by science on mankind; but, wherever we turn, we are met by undoubted proofs of its effect, in diminishing the inconveniences under which we labour, or augmenting the sources of our enjoyment. In treating this subject, the difficulty is, not to find matter, but to make selections from it, where so many interesting and important examples force themselves on our view.

The amount of fuel which, in the shape of coal, has been provided for us is very great, but the supply is not inexhaustible. On public grounds, therefore, it becomes highly desirable to economise this important substance, but still more from considerations connected with private interest. In almost every article we purchase, the cost of its production depends, either directly or indirectly, on the cost of the fuel which has been employed in preparing it. With our ordinary modes of producing combustion, the waste of heat is enormous, and therefore the cost of the fuel is greatly augmented. This becomes apparent, if we consider the vast amount of heat carried away, along with the products of combustion, by the chimney; the effect really obtained from the fuel being due only to the excess of the heat produced by combustion over that existing at the time in the body to be heated. It is, for example, clear that, were the water in the boiler at the same temperature as the interior of the furnace, no additional heat would be communicated to it; and, by consequence, the whole of the heat produced by combustion would be carried up the chimney and wasted. The high temperature which, therefore, is required to maintain a difference between the temperature of the body to be heated, and that of the source whence the heat is obtained, is in itself another source of waste. The greater the heat of the furnace, the greater the loss

by radiation, and the greater the current of heated air which passes off into the external atmosphere; so that the very effort made to obtain a sufficient temperature renders the attainment of it still more difficult, and greatly increases the quantity of heat evolved without giving rise to any useful result.

These disadvantages attending combustion, as ordinarily effected, have long been a source of regret to manufacturers and men of science; and numberless efforts have been made, if not to get rid of them altogether, at least to diminish the loss which they cause. But very little was done in furtherance of this most desirable object, until the principle of the regenerative furnace was successfully applied. The evil was very difficult to be cured. The loss is chiefly caused by a great quantity of the heat being carried along with the products of combustion into the chimney: but lessening or impeding the current in the latter, by diminishing the supply of air, would render the combustion less intense, and therefore insufficient. The application of a principle, however, which has been long known, and in use in other ways, afforded a solution to the important problem, and without interfering in any manner with the amount of air supplied for combustion; while, at the same time, nearly all the heat contained in the products of combustion is intercepted and retained. The means employed for the purpose are so simple, that it is surprising their application was so long delayed. But so it is with nearly all great improvements in science. They depend on the easy application of some simple, and often well-known, principle: and they do not strike the minds of experimentalists at once, simply, perhaps, because it is intended that our intellectual development should in every way be gradual—one great truth in science not being rendered obvious to inquirers until those already known have been worked out and utilized.

The regenerative furnace, the invention of Mr. Siemens, thoroughly economises heat. It is believed to lessen the consumption of fuel to the extent of from forty to sixty per cent.; and, which is a matter of scarcely less importance in the production of iron, it allows inferior ores to be used. Other and greater advantages also accompany its use. By means of it a very intense heat may be obtained from the inferior kinds of fuel; and since only the gases obtained from the latter are brought into contact with the body to be heated, any deleterious ingredients it may contain cannot produce an injurious effect—which allows fuel, of little or no value hitherto, to be used with the very best results. As the gases and vapours evolved from the fuel are entirely consumed, not only is the smoke nuisance abated, but valuable matters, which ordinarily pass off uncon-

sumed, to the great annoyance and injury of the neighbourhood, are rendered effective in the production of heat, and therefore in economising fuel.

Such being the advantages of the regenerative furnace, we cannot wonder at its having already come into very general use. The defects of the very best ordinary furnace are so great, and its incapability of applying to a useful purpose any more than a small portion of the excess of its temperature above that of the body to be operated on is so irremediable, that there is good reason to believe it wastes at least seventy-five per cent. of the effect producible from the fuel: a fact which clearly shows how desirable it is to supersede it by a better arrangement.

The general principle on which the action of the regenerative furnace depends, is easily understood: the details, which vary, though but slightly, with circumstances, are comparatively of but little interest, and, therefore, need not be noticed here. This furnace consists essentially of two parts; the gas-producer, which affords the heat, and the regenerator, which prevents it from being wasted. It is, in reality, a gas-furnace, and the fuel is used almost exclusively for the production of gas, the combustion of which is to furnish the heat required for the manufacturing purpose. The arrangements are such that the carbonic acid, formed by combustion in the furnace which acts as a gas-producer, is made to pass through incandescent fuel. It is thus changed into carbonic oxide, which passes off along with the other inflammable gases that have been evolved from the fuel, and also with the air which is heated by combustion of the carbon during the formation of the carbonic acid, most of which with the ordinary furnace escape uncombined, and, therefore, without evolving heat, into the chimney, and are lost. These gases, raised to a high temperature by the burning fuel in the producer, pass into the chamber where they are to be consumed, and along with them hydrogen and carbonic oxide, furnished by decomposition of some vapour of water, that has been transmitted through the intensely-ignited fuel in the producer along with the air required for the support of combustion. The amount of this gaseous mixture, and, therefore, the amount of the heat evolved, are completely under control, as these depend on the quantity of air admitted into the furnace of the producer.

After the gases have been burned in the chamber, and the heat set free by them has been applied to the manufacturing or other purpose for which it is required, they are not allowed to pass directly into the atmosphere; since this would cause a large quantity of the heat which has been obtained from the fuel to be lost. Under the combustion-chamber are placed

two pairs of regenerators, each of which consists of a great number of small rectangular tubes, formed of refractory bricks: and while the products of combustion pass from one end of the combustion-chamber through one pair of these regenerators, and are thus deprived of nearly all the heat they contain before escaping into the atmosphere, the air by which combustion is effected in the combustion-chamber and which enters by its other end, is supplied through the other pair of regenerators, that have been previously heated to a very high temperature by the passage through them from the combustion-chamber of the products of combustion. The heat carried away from the combustion-chamber is thus brought back to it and economized. A very simple valve alters the connections in such a way that, when one pair of regenerators is being cooled by the passage through them, in succession, of air from the atmosphere, the other pair is being heated by the passage through them, in succession, of the products of combustion: the pair previously heated being placed in connection with the atmosphere, that the temperature of the air intended for the support of combustion may in traversing them be heated: and the pair previously cooled being placed in connection with the combustion-chamber, that they may absorb the heat which without them would pass into the atmosphere and be wasted. The alteration of this valve is the only portion of the apparatus that requires attention; it must be reversed about every half hour, but it would not be impossible to render even this movement automatic. The fuel is supplied to the gas-producer in large quantities at a time, and in such a way that it tumbles down of itself along an inclined plane, according as that in the lower part of the furnace is consumed: it is thus deposited on the intensely-ignited fuel according as it is required. The regenerators deprive the products of combustion so completely of their heat that when passing into the atmosphere, they are rarely hot enough to singe paper.

It is clear that the principle of the regenerator is not new: the ingenuity and value of the invention consists in its being the application of a principle already in use for another purpose. It has, indeed, been applied in various ways. Bolton adopted it to a certain extent when, in the beginning of this century, he invented the tubular boiler. The tubes, by subdividing the products of combustion, and exposing them to a large surface suited to absorb their heat, greatly economized heat, by diminishing the quantity carried off into the atmosphere: and the very great value of the principle has been proved by the almost general use of tubular boilers. The regenerator is, however, still more exactly represented by the well-known apparatus termed a "respirator," which performs

on a small scale, the very same office for the air passing to and from the lungs as Mr. Siemen's regenerator performs for that passing to and from the combustion-chamber. The wire gauze of the respirator absorbs the heat passing off with the gases which leave the lungs during expiration, and gives it back to those entering the lungs during inspiration. Thus, not only is cold air, which might be injurious to persons of a delicate constitution prevented from passing into the lungs, but the heat produced by combustion within the body is economized. The action, and, indeed, the very construction of the regenerator being so similar to those of the respirator, it is extraordinary that the latter was not invented long ago.

There is one drawback to a general use of the regenerative furnace—the complicated form of the regenerators, and a comparatively expensive forms and material employed in its construction. Moreover, it cannot well be used, except on a large scale. One, at least, of the advantages possessed by the regenerative furnace may, however, be obtained by other and simpler means—the removal of the smoke nuisance, which involves the economization of fuel, and the prevention of mischief to health, as well as the production of that dingy hue, which casts a gloom over all our great centres of manufacture. Legislation, both here and in other countries, has not been wanting in efforts to put an end to the evils caused by pouring enormous quantities of dense smoke into the atmosphere, but its success has been only partial. Manufacturers are liable to a penalty of five pounds a day, if they do not consume their smoke; yet, such are their profits, and such, in some instances, the supposed necessities of trade, that they not unfrequently prefer paying this penalty to being, as they believe, impeded in carrying on their business. Nevertheless, it may be safely affirmed that there is no branch of manufacture that, for its existence, or even its prosperity, requires the production of unconsumed smoke. Nor is there any that would not be carried on more economically, were the smoke — which for the most part consists in very valuable constituents of the fuel—consumed in the furnaces. There is nothing to prevent this, except the ignorance or apathy of manufacturers themselves. To no subject has science devoted more attention than that of the consumption of smoke; and in none has it been more successful, since, in revealing the laws of combustion, it has suggested the means by which the consumption of smoke may be easily effected—at least in the furnace of the manufacturer, where the production of heat is the only object sought to be attained.

The unburned carbon, which causes the dark colour of smoke, is both the most mischievous and most wasteful of its

constituents. To get rid of this is the special object of all attempts at smoke-prevention, and it involves no difficulty which science is unable to overcome. One of the most remarkable contrivances which have been suggested for the purpose, consists in burning the fuel from the upper surface downwards, so as to bring the inflammable gases, properly admixed with air, in contact with fuel at a high temperature—a principle which, in various ways, and for a long period, has been used for the purpose; though, from the imperfect methods employed for carrying it out, not with all the success that might have been expected. The method which has been found to answer best consists in admitting air and coal, in small quantities at a time, through the top of the furnace, the direction of the draught being downwards through the burning combustibles. With another, and very effective arrangement, a steam coil is placed behind the fire bridge. When the steam it contains is superheated, it is thrown on the burning fuel, and, mixing with the products of combustion, it keeps them at a proper temperature, until there is time, and a sufficient supply of air to effect their complete combustion.

But even less complicated means than these, suggested by science, have been found, when carefully used, sufficient to prevent the escape of smoke from the chimney. It is merely necessary to supply the fuel in small quantities at a time, and to place it at first outside that which is already in a state of intense ignition. The gases which are thus evolved, and have been properly mixed with air, pass over the burning fuel, and are consumed. So effective is this simple, but scientific mode of proceeding, that the French Government considers it sufficient to effect all that the law can reasonably require with regard to the consumption of smoke.

There is one kind of smoke produced in vast quantities, which is far more mischievous than any other—that evolved by copper-smelting works—and yet its prevention has hitherto scarcely been hoped for, even by the most sanguine. It is highly injurious to health, and so destructive to vegetation, that it is impossible for plants of any kind to exist within its influence; so that large sums are often paid by the owners of metallurgical establishments, as compensation for the damage which they cause. As in every other case in which smoke is permitted to escape into the atmosphere, but to a still greater extent, it supposes the loss of a valuable material.

Science has, however, at last suggested a way to prevent all the waste and mischief caused by this poisonous smoke. A chemist at Friberg has recently invented a roasting furnace, which not only prevents the passage of any deleterious substance into the atmosphere, but changes what has

hitherto been a source of annoyance and danger into the means of producing a considerable income. In the ordinary processes, the copper pyrites, after having been stamped, is formed with clay or loam into balls, which are dried, and then roasted in kilns; or the pyrites, having been pounded, is spread on beds of fire-clay, where it is exposed to a high temperature, being kept constantly stirred, for the purpose of exposing fresh surfaces to the air. The sulphurous vapours thus evolved pass directly into the atmosphere. In the improved method, a furnace which consists of a vertical chamber of fire-brick, and contains a number of horizontal bearers of the same material, regularly distributed through it is used. These bearers uniformly intercept the crushed ore as it is discharged from feeding-boxes at the top of the furnace; and when the flat surface of the upper bearer contains as much as it will hold, the surplus fall on the next lower, and from that to the one still lower, and so on, until it reaches the bottom, by which time it is considered to have parted with all its sulphur.

The gases evolved are transmitted to a large chamber, heating in their passage the pipes which supply air to the grate, and there deposit the dust from the roasted ore and the arsenious acid. They are then conveyed to the sulphuric acid chambers, where the sulphurous acid which they contain, and which has been produced by combustion of the sulphur contained in the copper pyrites, is condensed, sulphuric acid being formed from them in the usual way.

It has been calculated that from the copper smoke which hitherto has not only been wasted, but has been productive of so much mischief, 1000 tons of sulphuric acid may be made per week; and £4000 is said to have been paid to the inventor for the use of his patent right.

The next example to which I shall direct attention is one of the greatest triumphs ever achieved by science—the production of the most beautiful and valuable substances from coal-tar, one of the most worthless and least attractive matters with which we are familiar. Long as coal-tar has been known it was not until recently even suspected to be the source whence might be derived a number of chemical compounds, rivalling the rainbow in the brilliancy of their tints, and capable of affording dye-stuffs fitted to supersede those previously obtained from the most distant regions, and costing immense sums.

When coal-tar is distilled at a temperature gradually increasing in elevation, it affords, besides hydrogen, water, and ammonia, a number of neutral and basic substances, among which aniline ranks the highest in importance. So early as 1826, Unverdorben obtained from indigo a compound which,

from properties he found it to possess, he termed crystalline. Some years after Runge observed in the products obtained from coal-tar a material capable of affording, under the influence of chloride of lime, a beautiful violet, which he called kyanol. At a subsequent period, Fritzsche, when studying the properties of crystalline, came to the conclusion that aniline would be a more suitable designation for it; and about the same time Zinin produced a similar compound from coal-tar, and gave it the name of benzidan. Still further investigation showed that crystalline or aniline, kyanol, and benzidan, were all identical, though derived from so very different sources; and it was found that this substance could be most conveniently procured from coal-tar; not, indeed, directly, but indirectly, by conversion of benzol, which is found in the tar in very large quantities.

Benzol is a striking illustration of the way in which the valuable properties of a substance may long remain dormant. It was discovered by Faraday in 1825; but it remained for years a mere scientific curiosity, though it may be obtained with ease, and to any amount, from the naphtha of coal-tar, by fractional distillation, its boiling point being 80° cent. It is readily converted into aniline, by submitting it to the action of fuming nitric acid: which transforms it into nitrobenzol, or nitrobenzine, the well known artificial essence of bitter almonds, discovered by Mitscherlich; and then changing the nitrobenzine into aniline, by means of reducing agents, such as sulphuretted hydrogen, or, which is usually employed in practice, acetic acid and metallic iron.

Aniline, though colourless, is the source of beautiful colours, the number of which is already very considerable, and is being continually increased. It was first observed in 1835, that a solution of chloride of lime imparts to it a blue colour; and in 1853 it was discovered that aniline violet, a blue-black precipitate, is thrown down from a cold dilute solution of aniline in sulphuric acid by a cold dilute solution of bichromate of potash. Aniline violet, which has received different names, may now be prepared in various ways.

In 1859, MM. Verquin and Renard practically discovered aniline red, or rosaniline. It is obtained without difficulty, by boiling for about a quarter of an hour a mixture containing ten per cent. aniline and about seven per cent. chloride of tin; the result being a liquid which is of so intense a colour as to appear almost black, but which is fitted at once, by mere dilution, for the use of the dyer. Rosaniline forms a number of very beautiful salts.

Aniline yellow, or crysaniline, another important derivative of aniline, is obtained from the residue which is left

after rosaniline has been extracted, by means of a current of vapour which causes the solution of a certain amount of crysaniline, that may be precipitated by nitric acid or a nitrate.

Aniline green, or emeraldine, is one of the most beautiful of the aniline colours. Several substances produce a blue tint in aniline, on account of the production of aniline blue. The latter is changed into emeraldine by acids.

It is not necessary here to describe the modes of obtaining the many other colours obtained from aniline. Not only may the ordinary and well-known tints be obtained from it, but new and exquisite shades which were hitherto unknown. The intensely deep colour of some of its derivatives is almost beyond belief. The sea has been dyed for a great distance, in all directions, so as to resemble blood, by the accidental spilling of some vessels containing one of them. The dye-stuffs afforded by it are not less remarkable for their delicacy and beauty than their intensity; and if some of them are deficient in permanency, it is an imperfection which, from what has been already done, we may reasonably hope will, at no distant period, be altogether removed. Every day adds something to our knowledge of the solvents which are suited to them, and the proper modes of applying them, and more widely extends the sphere of their utility. Perkin was the first who applied the aniline colours to dying; and the discovery of their suitableness for this purpose has, in a commercial point of view, been productive of enormous profit. Until recently, their use has been confined to dying; but it is now possible to employ them in oil painting, to the other excellent qualities of which they impart their own extraordinary beauty and brilliancy; and thus they wonderfully augment the resources of one of the noblest arts.

The aniline dyes afford another illustration of the gradual development which takes place in so many, if not all, of the great and practical additions which are made to our knowledge. Many years elapsed between the first step in the path which led to such extraordinary results and the full attainment of them. Upwards of thirty years ago, Runge made known to the world the very curious coloured reactions of aniline, a property which it might well be expected would have awakened the most lively curiosity, and led to extensive, persevering, and successful researches. Such, however, was not the case; his experiments were not repeated for twenty years! not, indeed, until M. Gerbert Keller, in obtaining aniline red, by means of oxysalts and oxacids, opened a new and irresistibly tempting field to discoverers, was the public interest thoroughly excited, and the zeal of men of science enlisted in the

prosecution of inquiries which promised so much, and very soon realized all they promised.

The history of science abounds with similar examples. The cooling of the smelting-furnace by the air introduced for the support of combustion was manifestly a mistake; yet who, for centuries, ever thought of adopting the hot air blast, an improvement which might almost be said to force itself on the attention of the iron-master. It might be supposed, indeed, that, if hot air were used, less fuel might be consumed in the actual process of smelting, but that the difference would be made up by what would be required for raising the temperature of the blast. Such was the objection made to the hot blast when it was first introduced, and it is still made by a few; for philosophical or manufacturing prejudices, like others, are not easily laid aside. But the advantage of the hot blast was not to be looked for merely in a saving of fuel—though even this is effected by it. Not only is the cost of production diminished, but the quantity producible in a given time is increased, and the quality of the product is so much improved, that a good iron may be made from bad and hitherto almost worthless ores, and iron of superior excellence from those which formerly afforded what was only tolerable. No improvement ever contributed so greatly to the advancement of the iron trade.

The same valuable principle may be applicable to more than one branch of manufacture. The use of heated air, which was found so advantageous in the manufacture of iron, has, more recently still, been found equally profitable in the manufacture of sugar: and one of the most efficacious means of avoiding loss by the formation of uncrystallizable sugar during the evaporation of the cane-juice, consists in the removal of the moisture by means of air at a high temperature. It is remarkable that, however great the heat used in this way, the sugar is not injured; yet, when the ordinary processes are employed, the temperature must be kept as low as possible—which rendered the evaporation of the juice *in vacuo* necessary: an improvement for which, also, the sugar-manufacturer was indebted to science. There is no contradiction between the effect of the heat in the one case and the other. When heated air is employed, the heat is carried away by the evaporated water before it can produce a mischievous effect.

A retrospect, however imperfect from its indispensable brevity, of the benefits conferred by science on arts and manufactures, cannot be otherwise than interesting and advantageous. The resources of science being inexhaustible, a survey of what has been already done must necessarily incite to new efforts in the future. The application of scientific dis-

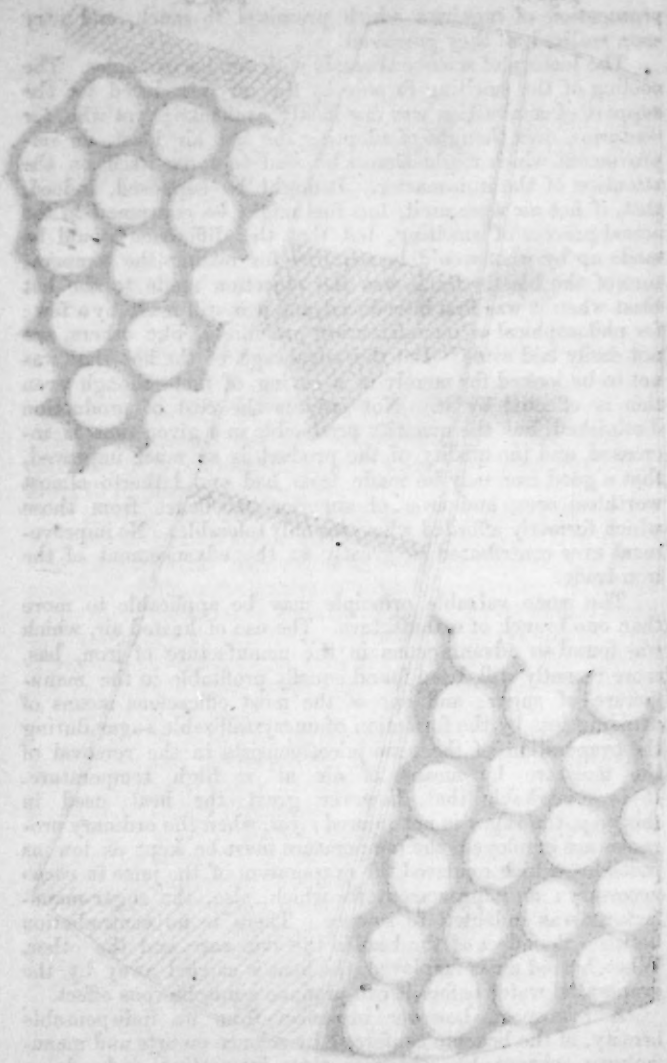
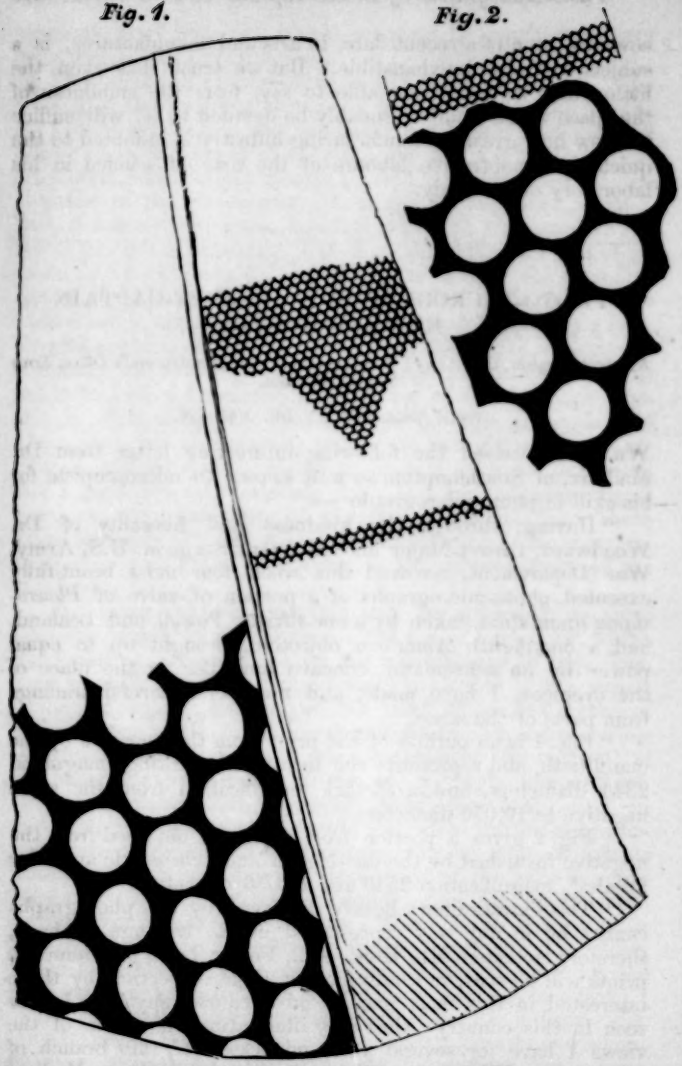


Fig. 1. *Fig. 2.*



PART OF VALVE OF PLEUROSIGMA ANGULATUM.

Fig. 1. × 2344 and 19,050 diameters. Fig. 2. × 2540 and 19,050 diameters.
From Photo-Micrographs by Brevet-Captain Edward Curtis.

coveries, even of a recent date, to arts and manufactures, is a subject well nigh inexhaustible. But we trust that even the little which we have been able to say, from the smallness of the space which could reasonably be devoted to it, will suffice to show how greatly manufacturing industry is indebted to the quiet and unobtrusive labours of the man of science in his laboratory or his study.

PHOTO-MICROGRAPHS BY BREVET-CAPTAIN EDWARD CURTIS,

Assistant-Surgeon, U.S. Army; War Department, Surgeon-General's Office, Army Medical Museum.

WITH REMARKS BY DR. MADDOX.

We have received the following interesting letter from Dr. Maddox, of Southampton, so well known to microscopists for his skill in photo-micrography:—

"Having, through the kindness and liberality of Dr. Woodward, Brevet-Major and Assistant-Surgeon, U.S. Army, War Department, received this week four most beautifully executed photo-micrographs of a portion of valve of *Pleurosigma angulatum*, taken by a one-fiftieth Powell and Lealand, and a one-eighth American objective, brought up to equal power by an achromatic concave amplifier in the place of the eyepiece, I have made, and now send, careful tracings from parts of the same.

"Fig. 1 is an outline of the print from the negative by the one-fiftieth, and represents the hexagonal markings magnified 2344 diameters, and a further amplification from the same negative to 19,050 diameters.

"Fig. 2 gives a portion from the print obtained from the negative furnished by the one-eighth and achromatic amplifier (Wales), magnification 2540 and 19,050 diameters.

"The extraordinary beauty displayed by the photographs cannot be in any way represented in the tracings. I have, therefore, solicited Mr. How, of 2, Foster Lane, to whom the prints will be sent, to kindly permit their inspection by those interested in this most marked advance over anything I have seen in this country; thus fully illustrating the value of the views I have for several years advocated of this branch of microscopy. When we see the authorities in the Army Medical Department of the United States giving their attention to this subject, and so perfectly justifying the same by such magnificent results as have been obtained at the laboratory of the

Army Medical Museum by Dr. Edward Curtis, I feel the necessity of further soliciting attention to its utility and future promise. Of the two prints, respectively from negatives by the one-fiftieth and one-eighth, no doubt preference, if sharpness and delicacy of outline be selected, would be given to the former; but there is such wonderful softness and flatness of field in the latter, that it may safely compete with the one-fiftieth. In the centre of nearly all the hexagonal markings a minute and faintly traced punctuation may be observed; and in the enlargement from this negative the markings are, perhaps, of better figure and equal beauty with that from the one-fiftieth objective.

"Of the method or *modus operandi*, Dr. Woodward in his letter does not speak, but the prints point to the plan as being perfect. I am not aware whether the valve of the diatom was covered or uncovered, balsam mounted or dry; these are points I hope to ascertain from him ere long. Disputants may now take up their cudgels as to the number of lines or dots, or transparent areas, by counting them clearly and without fatigue. On the one row selected are 27 clearly defined spaces. The interstices of the enlargement 19,050 are quite black, but without harsh edges to the central area. It is curious to see how the inner hexagonal boundaries have passed into nearly perfect circles unless due to the part chosen for enlargement. A slight sun-spot marks each negative, but not offensively; or if it be not a delicate sun-spot, it may be indicative of the part adherent to the glass slide. The field covered is eight inches. Trusting you may justify the above by your own remarks."

POPULAR ASTRONOMY.*

ALTHOUGH France has enjoyed, in many departments, a superiority over England, so far as regards the price and quality of text-books for professed students, she has been, and still is, far behind us in the production of popular scientific works addressed to a large body of intelligent readers. The fact is, that from political and social causes the middle class in France is less educated than that of England; and while no country can surpass her in the numbers of great men she has produced in nearly every branch of inquiry, she has not grown, like England, a very numerous crop of scientific amateurs. If we refer, for example, to the list of private observatories given in *Annuaire du Cosmos*, France does not claim one, while England has more than twenty that are known and acknowledged, besides swarms of minor value. A comparison of one of the best French books on the microscope, that of Chevallier, with Dr. Carpenter's compendious treatise, or with the *Micrographic Dictionary*, indicates a similar superiority in the popularity which microscopic pursuits enjoy in this country, and it is curious to find such observers as Quatrefages lamenting the *want* of powers which English makers have produced for the last twelve or twenty years. The appearance of M. Guillemin's splendid work is an indication that our neighbours intend to have their phalanx of able astronomic amateurs; and the fact that the book has rapidly passed through two editions, and that the third is now on sale, proves that the taste of the French people for science is increasing, and that their ideas of popular education are becoming enlarged.

It is in no spirit of depreciation of literary culture that we urge the paramount importance of scientific instruction. It is by far the best, if not the only, means of giving to a nation a character for accuracy and breadth of thought, and it is the most effective prophylactic against that flabbiness of intellect and morals that results from the poisonous doses of fiction which the numerous class of romance dram-drinkers are apt to imbibe. High class fiction, studied and understood, is, no doubt, an important element in mental training, but the comprehension of physical science methods, and the habit of applying them, as far as they will legitimately go, are, under all circumstances,

* *Le Ciel:* Notions d'Astronomie à l'usage des Gens du Monde et de la Jeunesse. Par Amadée Guillemin. Ouvrage illustré de 40 Grandes Planches dont 12 tirées en couleur, et 192 vignettes insérées dans le texte. Troisième Edition. Paris; Hachette and Cie. 1866.

The Heavens: an Illustrated Handbook of Popular Astronomy. By Amadée Guillemin. Edited by J. Norman Lockyer, F.R.A.S. London: Bentley.

of great value to individual progress, and the essential conditions of social development.

Excitement the mind will have, so long as it is active; and where there is not a fair foundation of accurate knowledge, and a capacity for appreciating the appeal which natural objects make to the faculties of wonder and imagination, the gratification of those faculties will be sought in some objectionable way. It is a great thing to be able to be appealed to by the sublime truths of the universe; and though every science is capable of leading its votaries into the regions of general ideas, and widely-operating laws, astronomy has always been felt to have a peculiar fascination, and to be capable, when well popularized, of gaining ardent disciples among all ranks of men.

No better book exists in any language than Sir J. Herschel's *Outlines of Astronomy*, and we have many works of various degrees of merit and demerit, which, avoiding profounder considerations, deal in a graphic style with the marvels of the sky. No *popular* treatise, however, appear to us, on the whole, equal to the imposing volume produced by M. Guillemin, in which a much larger amount of real science is introduced than is common in works designed for wide circulation, while a method of arrangement, which is in the main logical, a lucid style, and an abundance of pictorial illustration, renders the study of its pages easy, and invests them with a charm.

M. Guillemin commences his treatise with an account of the sun, and he recites a good story told by Arago of a professor who wished to give his pupils an idea of the dimensions of the great luminary as compared with the earth, and who showed them a heap containing fourteen *decalitres* of wheat, or nearly four bushels,* and explained that if one grain represented the earth, the whole mass, containing 1,400,000 of such grains, would represent the sun. To make the distance of the sun from the earth intelligible, M. Guillemin states that a railway train leaving the earth, and going at the rate of thirty miles an hour, would require rather more than 347 years to reach it; so that if such a train had started on January 1, 1866, it would be A.D. 2213 before it arrived at its destination. Both M. Guillemin and his translator adopt the old estimation of solar distance and of the velocity of light, but in this sort of calculation such trifles as a few thousands of miles make no difference, and those who are fond of arithmetic may substitute 186,000 miles per second, as the probable velocity of light, for the old calculation of 192,000, and make a corresponding diminution in the distance which separates the sun from ourselves.

* 14 Decalitres = 3 bushels 6·813 gallons.—*Darling's Metre Tables.*

M. Guillemin explains the principal theories which have been put forward to account for the peculiar appearances presented by sun spots, and Mr. Lockyer has added to the translation a valuable note on the same subject, taking notice of the latest views. We have laid before our readers, both in articles and in "Notes and Memoranda," the principal recent opinions and discoveries on this matter,* and we shall only now remark that all the evidence concurs in representing the sun as the scene of cyclonic or whirlpool storms of tremendous magnitude, and probably also of volcanic eruptions on an equally gigantic scale. Such incidents must give rise to ascending hot currents and to the descent of the colder atmosphere which De la Rue and other observers have shown to exist; and thus may be produced condensations and changes in luminosity capable of accounting for the appearances we behold.

M. Guillemin gives a sketch of enormous sun spots seen by Captain Davis, and he remarks that the biggest did not occupy less than 300,000 kilometres, or 186,000 miles, while its surface was equal to 25,000,000 square miles. Well may he exclaim that if such "spots" are fissures in the photosphere, our earth compared with them would only be like a rock in the crater of a volcano!

The real rate of the sun's rotation about its own axis is still unsettled. If the spots were fixed it would be easily arrived at, but, as Mr. Carrington has shown, they move across the sun with varying velocity, and thus some uncertainty attaches to the estimation of the length of the solar *day* (if such a term is admissible), which may be about twenty-six of our days in length. This would show an enormous velocity at the solar equator. M. Guillemin states that at a point on the equator the velocity of rotation is 2035 metres, or about $1\frac{1}{4}$ miles per second, $4\frac{1}{2}$ times the velocity of rotation at the terrestrial equator. With such a velocity of rotation, and with the mobile character of the solar envelope, if not of the great globe itself, it is surprising that no equatorial bulge is noticeable.

The light of the sun does not reach us equally from all parts of his surface. The luminous and chemical rays diminish from the centre to the margin as they pass through a greater or less extent of solar atmosphere in their journey towards us. The total amount of light given out by the sun could only be expressed in figures unintelligible from their magnitude. We can only receive an infinitesimal portion of the whole; and so of the heat. In illustration of the heat of the sun, M. Guillemin alludes to a passage from Sir J. Herschel, which we prefer

* See *Solar Physics*. Researches by De la Rue, Balfour Stewart, and Loewy, vol. viii. p. 450. Secchi and Fage on do., vol. vii. p. 270; and Chacornac, vol. vii. p. 272.

giving in the original words. Sir John says—"Supposing a cylinder of ice forty-five miles in diameter to be continually darted into the sun with the velocity of light, and that the water produced by its fusion were continually carried off, the heat now constantly given off by radiation would then be wholly expended in its liquefaction on the one hand, so as to leave no radiant surplus; while on the other the actual temperature at its surface would undergo no diminution."*

We have no cognisance from terrestrial experiments of the kind of chemical action that would take place at the enormous temperature of the sun. Probably all the compounds we are acquainted with would be dissociated, and many of our so-called "simple bodies" decomposed. Nevertheless, the spectroscope tells of sodium, iron, nickel, copper, zinc, and barium, but not of "gold, silver, mercury, lead, tin, silicon (so abundant on the earth), arsenic, strontion cadmium, or lithium."

In what way solar light and heat are produced, remains a mystery; most physicists have abandoned the idea that they are kept up by a bombardment of meteorites, and though Mr. Balfour Stewart has shown good reason for believing that the approach of large planets stirs up solar activities,† we must look to local conditions to explain why, and how, the enormous movements, of which the light and heat are manifestations, take place. Our sun appears to belong to a great group (genus or family) of which the so-called "fixed" stars are members, and when we see many of them waxing and waning in regular periods, and when we behold some of them, like the late "new star," blazing forth with prodigious and quickly terminating splendour, we cannot help admitting the probability that our sun may be a variable, however long the intervals that may elapse before any noticeable change occurs. A great hot globe, the seat of gigantic storms, and it may be of conflagrations, in which prodigious masses of matter change their conditions in brief periods of time, is scarcely likely to be the source of an equable and permanent force. In some long ages anterior to man it may have scorched the planets that it now genially warms, and at others it may have left them to freeze in the cold ether, or atmosphere, of space,‡ and without reckoning on the time when its shining may cease, and its matter be rearranged in new forms, we may speculate on sufficient changes in some imaginable number of centuries to affect in a material manner the climate of our globe.

* *Outlines of Astronomy*, p. 258, seventh edit.

† See Balfour Stewart "On the Origin of the Light of the Sun and Stars," in our vol. v., p. 448.

‡ M. Babinet thinks the glacial epoch may have resulted from a sudden diminution of solar heat.

It is not only small stars that are variable, nor only what are called "temporary stars" that have made quick transition from great splendour to feeble luminosity. Thus a star in Argo (η) which stood, next to Sirius in brightness, has experienced what M. Guillemin terms "astounding transformations." "Towards the end of the seventeenth century Eta in Argo was only a fourth magnitude star, but in less than a century afterwards it had reached the second magnitude. Sixty years still later, it had declined to its first intensity, to enlarge again up to 1826. Since that epoch it has passed through the most astonishing phases, oscillating between the first and second magnitudes, now equal to Alpha Crucis, then to Alpha Centauris, now surpassing Canopus, and finally approaching Sirius." In a note he adds that Mr. F. Abbott found that it reached the brightness of Sirius in 1843, and then passed through diminishing magnitudes, until in 1863 it was no longer visible to the naked eye.

Changes of magnitude or apparent lustre may or may not, according to circumstances, be connected with alteration in hue. Recent attention has been strongly called to these colour changes, some of which appear to take the form of periodical alternations, while others follow laws of which we have no idea.* Thus the ancients saw Sirius as a red star. He is now white, and does not present any indications of reverting to his former condition. Regular periodical changes in colour or brightness may result from the approach and recession of planets attending on stars, and which may excite them as Mr. Balfour Stewart conceives, but other colour changes may result from internal conditions, and it is possible that no star would be found invariable in this respect if watched for periods sufficiently long. Thus among the future contingences that may await our earth may be that of some day receiving coloured light instead of white, a modification that would have a considerable effect upon animal and vegetable life.

The heavens become the more deeply interesting as they lose the attribute of unchangeableness formerly ascribed to them, and when we gaze upon constellations that impress us with their magnificence, and serve as boundary marks in space, tones of wonder and awe vibrate through the mind, as we reflect that some at least of these combinations are breaking up, that, if humanity endures long enough, some future members of our race will not only find that our present pole-star has forsaken the pole, but that the Cross has ceased to be the glory

* M. Guillemin's plate of coloured stars has not been prepared with sufficient care. γ Leonis is a complete failure, and no telescope in existence can show the close couple in γ Andromedæ as represented. The colours of Albireo β Cygni are badly given.

of the southern hemisphere through its components wandering, as Humboldt tells us, in different ways.*

M. Guillemin gives a table of the computed velocity with which certain stars move. Arcturus is put down as traversing fifty-four miles in a second, 61 Cygni forty miles in the same time, Capella thirty-nine, Sirius fourteen, Vega thirteen, and the Pole Star one and a half miles. Our sun and his attendant planets appears to be moving towards some point in Hercules with a velocity of about four miles a second.

All the testimonies of science concur in pointing to the oneness of the universe. We cannot, therefore, regard the grouping of stars as otherwise than resulting from some general law, and to that same, or to some other great law, must be ascribed the singular and frequently fantastic forms in which nebulous matter is arranged. M. Guillemin gives, from various authorities, a considerable number of woodcuts and plates illustrating clusters and nebulæ, and the contemplation of such delineations is well calculated to impel his readers towards the contemplation of the objects themselves.†

Mr. Huggins's discoveries‡ have demonstrated the existence of real nebula as contradistinguished from star clusters appearing nebulous simply through their remoteness from our earth. It was a very illogical proceeding on the part of many astronomers to imagine that because *some* so-called nebulæ were resolved by large telescopes, *all* could be resolved if sufficiently powerful instruments were provided; and the evidence to the contrary afforded by spectrum analysis not only restores to the heavens one portion of their rich variety of objects, but once more opens wide the doors of rational speculation which were too summarily closed.

It is not excusable that M. Guillemin, in his *third* edition, and after his attention had been called to the matter by the notes which Mr. Lockyer appended to the English translation, should persist in treating the subject of nebulæ almost as if Mr. Huggins's discoveries had not been made, nor is there any logical propriety in his separation of star clusters into two groups,

* The change in the apparent position of the pole star arises from peculiarities in the earth's motion by which its pole does not always point to the same spot in the heavens. This source of change in the appearance of the stars, as seen from the earth, must not be confounded with changes arising from their proper motions.

† We are often asked what sized telescopes will show such objects. This depends very much on climate and weather. Many of the easier clusters afford beautiful sights on clear nights, with refractors as small as three inches, which will also give a notion of the brighter and larger nebula, such as those of Orion and Andromeda. Mr. With's 6½-inch mirrors act beautifully, and with more power than might have been expected on many nebula. Larger apertures will of course do more; but the very largest are required to follow the observations of Ross, Lassell, Bond, etc.

‡ See especially *Celestial Chemistry*, in our vol. vi., p. 387.

one of which is dealt with under the head of nebulæ. More information is needed before a complete classification can be made, but Mr. Lockyer has shown the right method by placing known telescopic clusters side by side with clusters visible to the naked eye. M. Guillemin strangely divides his description of nebulæ of regular form by interpolating in the midst of it remarks and sketches of some that are irregular in shape. Mr. Lockyer has corrected this awkwardness in his edition.

It is impossible to conceive of the laws of aggregation which operate upon nebulous matter, and nothing can be more surprising and extraordinary than the fantastical forms which some of the nebulæ assume. Waiting for information on this highly curious subject, we pass to the so-called "planetary nebulæ," which M. Guillemin erroneously describes as having uniformly luminous disks. Sir J. Herschel says of them, "They have, as their name imports, a near, and in some instances a perfect resemblance to planets presenting disks round or slightly oval, in some quite sharply terminated, in others a little hazy or softened at the borders. Their light is in some perfectly equable, in others mottled, and of a very peculiar texture, as if curdled."* He adds, "The largest of these objects is situated somewhat south of the parallel of β Ursa Majoris, and about 12^m following that star. Its apparent diameter is $2' 40''$, which, supposing it placed at a distance of not more than 61 Cygni, would imply a linear one seven times greater than that of the orbit of Neptune." The absence of the appearance of condensation in the centre of these planetary nebulæ has suggested the notion that they may be hollow shells, and, so far as they have been examined by Mr. Huggins, they afford evidence of gaseous structure.

The discovery of variable nebulæ, and the evidence adduced of changes in the form of some of the principal nebulæ, show that these bodies are performing internal work, resulting in alterations in shape and possibly of constitution also. The most remarkable of these changes is thus alluded to by Sir John Herschel, in his *Catalogue of Nebulæ*, etc., p. 24, No. 2197, "According to a letter from Mr. Eyre B. Powell, of Madras, a most extraordinary change has taken place in this nebula (η Argus) since my figure of it was delineated. He states that at the southern end of the curious oval vacuity close to the great star, which was *decidedly* closed when I depicted it, is now *decidedly* open. Should this be established, it will be the most extraordinary fact that has yet appeared in the history of a nebula." Those who have visited the southern hemisphere describe this nebula as an object of surpassing

* *Outlines of Astronomy.*

grandeur, exceeding the great Orion nebula in splendour, and also in eccentric beauty of form.

What are nebulæ properly so-called? Are they gaseous matter resulting from the dissipation of the solid materials of former stars, or are they such matter in process of condensation? Both suppositions are probable, if our minds are impressed with the belief that incessant modification, the resolution of old forms, and the re-arrangement of their matter into new forms, is the rule throughout the universe. Hitherto, however, not even spectrum analysis has established a connection of this kind between nebula and stars. It may exist, but it is not yet proved; and if, on the one hand, the opponents of free speculation on these subjects ask the supporters of the nebular hypothesis for more proof than can at present be adduced, they are entitled to point out in reply that, in a matter subjected to so little positive investigation, negative evidence against that hypothesis is not entitled to much worth.

A few words on the two volumes before us. On the whole, the plates in the French edition are the best, and the type is larger and handsomer. Mr. Lockyer has been an "able editor" of the English edition, and if he had selected a publisher from whom students expect to receive works of a solid and enduring character, we have no doubt the popularity of the English version would have been as great in England as that of the French edition has been in France.

EQUIGRAPHIC PROJECTIONS OF THE GLOBE.

BY RICHARD A. PROCTOR, B.A.

(*With Illustrations.*)

In this paper the term "projection" is to be understood in the sense used in mapping—viz., to signify any method of construction by which the meridians and parallels of a map may be laid down.

Since it is impossible to represent any portion of a globe without distortion, the map-maker seeks to satisfy the conditions which seem most important for the particular purpose he may have in view. Thus he may propose to himself the construction of a map in which distances measured from the centre, or along a latitude-parallel, shall be correctly given, as in the *equidistant* projection, and in Flamsteed's projection, respectively, or in which errors of distance shall be distributed as equally as possible; or he may aim chiefly to obtain correctness of shape, either in large figures—a problem approximately solved in the *conical* projection, or in small figures, a problem completely solved in the *stereographic* and *Mercator's* projections, and which may be solved in an indefinite number of ways; or, again, he may propose that certain lines on the globe shall be represented by straight lines in the map—as great circles and rhumb-lines, for instance, are represented in the *gnomonic* and *Mercator's* projections respectively. These and many other problems may be proposed, and maps constructed to fulfil such conditions, will have a special value for special purposes. The problem I now propose to examine is that of the construction of maps in which equal areas on the globe shall be represented by equal areas on the map. M. Babinet, who first proposed such a construction, called it the *homolographic* projection of the globe; the term *equigraphic* seems preferable, however.

It is stated in Nichol's *Cyclopædia of the Physical Sciences*, that Cauchy, the celebrated mathematician, solved Babinet's problem, though it is not easy to see what difficulty Babinet could have found, since the problem admits of many simple solutions. I am unable to say whether Cauchy's solution corresponds with any of those I am about to indicate. The advantages of equigraphic projection for special purposes are obvious. Maps thus constructed are not necessarily much distorted; but of course when the whole of the sphere is represented in a single projection, as in the figures which illustrate this article, the distortion is very great in parts of the map.

The method illustrated in Fig. 1 results from the solution of the following problem:—Two neighbouring latitude-parallels

being taken, including between them a very narrow belt of surface, required to find a point on the polar axis from which this belt would be projected into a ring of equal area on the north-polar tangent-plane. The solution of this problem gives a formula from which it results that each such belt must be projected from a different point;* in other words, that there is no single point for which any finite area of the globe can be equigraphically projected. But the complete projection can be obtained in an elegant manner by a sort of double (true) projection. Imagine a hemispherical shell of twice the radius of the sphere standing on the centre of its curved surface upon a horizontal table; let the sphere be placed within the hemisphere, the north pole of the sphere coinciding with the point of contact of the hemisphere and table, so that the axis of the sphere is vertical, and the south pole coincides with the centre of the hemisphere. Now suppose both the sphere and the hemispherical shell to be transparent; the meridians, continent-outlines, etc., on the sphere opaque; and that a luminous point placed at the south pole of the sphere casts shadows of the opaque lines upon the hemispherical shell; then, if these shadows be traced in opaque lines, and the luminous point be removed vertically upwards to an indefinite distance, the lines traced on the hemisphere will be *orthographically* projected as shadows upon the plane table. Now it is easy to show that any small area on the sphere is increased by the first process, and the increased area diminished in the same proportion by the second process, so that the area of the final projection is equal to the true area on the globe—in other words, the final projection is *equigraphic*.

The construction for this projection is simple. If the meridians and parallels are to be drawn to every tenth degree, proceed as follows:—Describe a circle with a radius equal to twice that of the globe, to the scale of which the projection is to be drawn; divide the circumference to every fifth degree; draw a pencil-line from the centre to one of these divisions, and a series of other pencil-lines—which will cross the first at right angles—connecting divisions equidistant from the first on either side of it; describe circles concentric with the first through the points in which the first straight line is crossed by the others—these are the *parallels*; and lastly, draw straight lines from the centre to alternate divisions round the outer circle—these are the *meridians*. In other words, if we omit alternate meridians in the *polar orthographic* projection of the meridians and parallels of a *hemisphere* to every *fifth* degree, we have the

* The formula is $x = 2r\left(1 + \cos\frac{\lambda}{2}\right)$ where r is the radius of the sphere, λ the mid-latitude of the belt, and x the distance of the point of projection for the belt, from the north pole of the sphere.

Fig. 1.

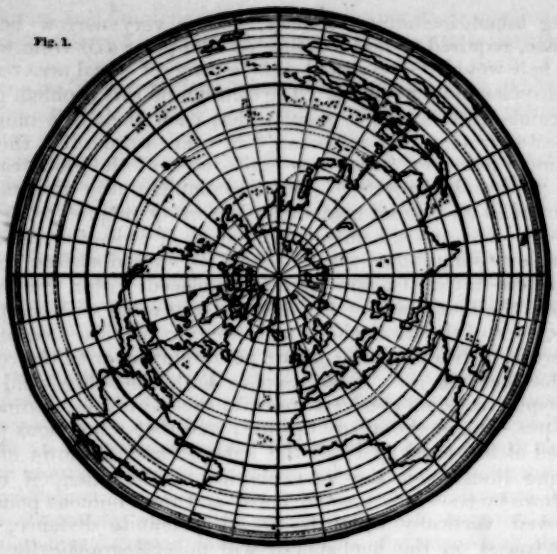
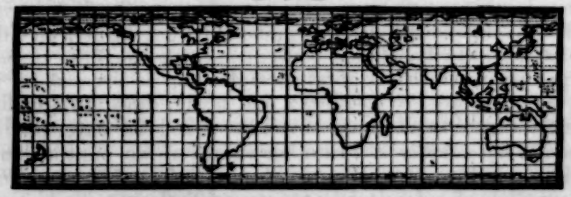
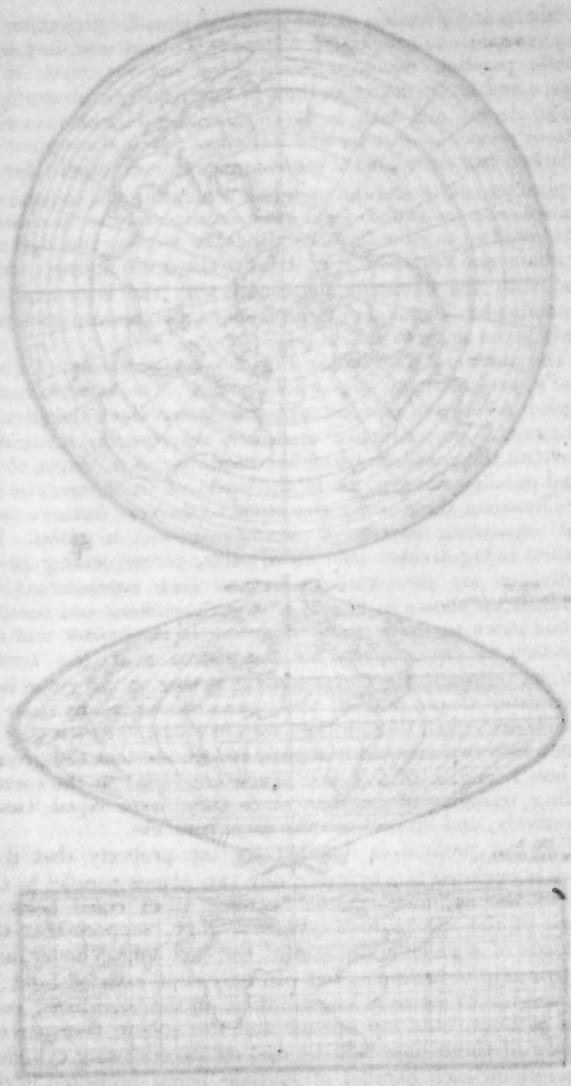


Fig. 2.
Scale two-thirds of Fig. 1.

Fig. 3.
Same scale as Fig. 2.



EQUIGRAPHIC PROJECTIONS OF THE GLOBE.



meridians and parallels of the *polar equigraphic* projection of a *complete sphere* to every *tenth* degree. We may now darken the middle parallel, which represents the equator, mark in the tropics and arctic circles in their proper places, as shown by the dotted circles, and draw in the continents and islands according to their proper longitudes and latitudes. It is convenient also to darken two meridians at right angles to each other; for this purpose we may select the meridian separating the old and new hemispheres (so-called) from each other, and the meridian at right angles to the former. In other words, the darkened meridians and parallel of Fig. 1 (as of the other figures) correspond with the circumferences, and with the horizontal and perpendicular diameters of the maps of two hemispheres commonly given in our atlases.

The method illustrated in Fig. 2 is an extension of Flamsteed's projection to the whole globe. The construction is simple: a series of equidistant parallels represent the parallels of latitude, a perpendicular cross-line representing a meridian bisects all the parallels, which are made equal in length to the actual parallels on a globe of the scale of the figure, the distance between them being also equal to the true distance (constant) separating successive parallels on such a globe. The parallels being divided into equal parts, corresponding points of division are connected by curved lines representing the meridians, as shown in Fig. 2, in which meridians and parallels are laid down to every tenth degree. It is obvious that this projection is equigraphic, for the spaces near the central meridian represent the corresponding spaces on the globe both in size and shape, and all the spaces between any pair of parallels are equal, though they vary in shape, for each may be divided into two unequal triangles, and we see that the greater and less triangles of any one space are equal to the corresponding triangles of another, since they have equal bases, respectively, and lie between the same parallels.

The last method is founded on the property that if a sphere is enclosed in a cylinder, any two planes parallel to the base of the cylinder enclose between them equal belts of surface of the sphere and cylinder. Now, suppose that the polar axis of a globe is the axis of the enclosing cylinder, and that this axis is luminous, but can only emit rays of light at right angles to its own length; then, if the meridians, continent-outlines, etc., are opaque and the sphere transparent, shadows of these lines will be cast on the enclosing cylinder, the points on each parallel of latitude being projected in the plane of their parallel, owing to the supposed peculiarity of the luminous axis. If, now, the cylinder be opened along a line parallel to its axis and unrolled, we shall obtain the equi-

graphic projection represented in Fig. 3. The construction is simple. Taking a horizontal cross-line to represent the equator, and therefore equal in length to the circumference of the globe, we divide it into equal parts, and through the points of division draw perpendiculars representing the meridians; these must be equal in length to the diameter of the globe, and be bisected by the equator. On the outside meridians describe semicircles (in pencil), and divide their circumferences into half as many equal parts as the equator was divided into, and through corresponding points of division draw parallels to the equator; these represent latitude-parallels, and in Fig. 3 meridians and parallels are drawn to every tenth degree.

There are many methods by which the globe may be equigraphically projected; the three just described are, however, the simplest in construction, and, in some respects, the best that can be devised. The qualities of these projections, and the purposes which maps formed upon them are best suited to fulfil, are different.

In the first projection we have a very accurate map of the north polar regions; the northern hemisphere is presented without great distortion, but all the outlines of the southern hemisphere are much distorted. The projection can, of course, be applied to the southern quite as well as to the northern hemisphere; however, as the greater portion of the land lies north of the equator, the northern is obviously the proper pole for the centre of the projection, if only one map is to be drawn. It is not advisable to present the northern and southern *hemispheres* in two maps, since one of the chief advantages of this, as of most polar maps, is that it indicates the connection between the different parts of the globe. It would be well, however, supposing maps of this sort were to be introduced into atlases, either to give two maps of the complete sphere, or at least to supplement the north polar map with a map of southern regions from the pole to the tropic of Capricorn.

Such a map as Fig. 1, on a suitable scale, would form a useful addition to works on physical geography. Consider, for instance, the following extracts from Humboldt's *Cosmos*:—

"The superficial extent of dry land, compared with that of the liquid element, is as 1 : 2·8, or, according to Rigaud, as 100 : 270.* The islands form scarcely one twenty-third part of the continental masses, which are so unequally distributed that the northern hemisphere contains three times as much land as the southern, which is pre-eminently oceanic. . . . The liquid element predominates equally in the space comprised between the eastern shores of the old and the western shores

* According to others, 100 : 284.

of the new continent, where it is only interrupted by a few scattered groups of islands. . . . The southern hemisphere and the western, from the meridian of Teneriffe, are therefore the most oceanic portions of the globe." "The two great insular masses or continents—eastern and western, old and new—present some striking contrasts, and, at the same time, some analogies worthy of notice. Their major axes are in opposite directions;" the eastern extending from east to west, the western from north to south, roughly. "On the other hand, both continents are terminated towards the north, nearly on the seventieth parallel; and towards the south run into pyramidal terminations, having submarine prolongations indicated by islands and shoals." Some of these remarks, it will be noticed, are satisfactorily illustrated by a map on Mercator's projection, others by any map on an equigraphic projection; but the polar equigraphic projection is the only satisfactory illustration of the complete series of remarks.

I may notice, in this connection, a remark of Humboldt's, which illustrates the singular liability even of the best observers to error when intent on establishing a favourite view. Humboldt, in labouring to establish the prevalence of law in the figuration of the continents, adduces the following instance:—"We perceive," he says, "that the terminations of the three continents, *i. e.*, the southern extremities of Africa, Australia, and America, successively approach nearer to the South Pole;" apparently not noticing that three promontories round a globe must necessarily exhibit such successive approach, either in an easterly or westerly direction. In fact, the arrangement actually observed is exactly that which seems least indicative of law, since the points of Africa and America, which are those separated by the shortest difference of longitude, are also those which differ most in latitude. A law might seem to be suggested if Africa extended to a southern latitude intermediate between the latitudes limiting Australia and South America, or (in a less degree) if South America extended to a latitude intermediate between the latitudes limiting Australia and Africa. In either case, however, the certainty that the three points must lie in order would be sufficient to weaken any evidence founded on the different distances (in longitude) between them. Humboldt adds, that "New Zealand seems to form a regular intermediate member between Australia and South America." But if New Zealand is to be considered in such an inquiry, then Madagascar, which is larger than all the New Zealand islands together, must also be considered; and the assumed law is not followed in the case of Madagascar. If it be argued that Madagascar is clearly only a "submarine prolongation" of Africa, it may be

answered that it is quite as clear that Australia itself, and all the islands of the Australian Polynesia, are only submarine prolongations of the Asiatic continent (see Fig. 1).*

Such a projection as that of Fig. 1 is especially adapted to illustrate works on the physical geography of the sea, since the correct presentation of areas is obviously important in illustrating the subjects treated of in such works; and it is also important that currents, tidal wave-fronts, tracks of ships, etc., should be presented without the breaks which occur in maps on Mercator's projection. There are many passages, for instance, in Maury's *Physical Geography of the Sea*, which seem to require the illustration afforded by maps on the polar equigraphic projection. I will select one on a subject of some interest. In this case the illustration afforded by the north polar map is such as to throw doubt on conclusions, which, judged by Mercator's chart, seem sufficiently plausible :—

In the earlier editions of this interesting work Captain Maury had expressed the opinion that there exists "a basin of considerable extent in the frozen ocean, supplied by water coming in at the bottom, and rising up at the top, with a temperature not below 28°, the freezing point of sea-water." He cited in evidence the facts that "whales have been taken near Behring's Strait with harpoons in them bearing the stamp of ships cruising on the Baffin's Bay side of the American continent;" that "icebergs high above the water, and therefore extending more than seven times as far below the surface, "have been seen drifting rapidly northwards through Davis' Strait against a strong surface current,"† showing that there is a powerful under-current towards the north pole; that De Haven saw a "water-sky" northward and westward from Wellington Channel; and lastly, that the birds and animals of arctic regions migrate *northwards* in search of milder climates. This last circumstance, by the way, does not afford such strong evidence as at first sight it appears to do, since, owing to the peculiar disposition of the autumn and winter isotherms, a course very nearly northerly would in many cases be the proper course for arctic birds and animals seeking the nearest spots

* It may be noticed that the mathematical chance of four promontories round a globe forming a regular progression, either in an easterly or westerly direction, is $\frac{1}{3}$rd, of five $\frac{1}{15}$th, of six $\frac{1}{60}$th, and so on; the chance of n promontories forming such a progression, in either way, being $\frac{2}{\lfloor n-1}$, where $\lfloor n-1$ means the continued product of the natural numbers from 1 to $n-1$. In other words, the "odds" against these respective events are 2 to 1, 11 to 1, 59 to 1, and $(\frac{1}{2}\lfloor n-1 - 1)$ to 1, respectively.

† Even in midwinter. Thus Captain Duncan, of the whale-ship "Dundee," writes—"December 18th (1826). It was awful to behold the immense icebergs working their way to the north-east from us, and not one drop of water to be seen; they were working themselves right through the middle of the ice."

combining a suitable climate with the conditions suited to the existence of these creatures. For instance, the shortest course from Parry Islands to Spitzbergen, with its comparatively mild winter climate, would pass very near the North Pole. However, it may be considered as established, that (in summer certainly, and probably in winter) large open seas exist in the arctic regions.

But in treating of this subject in later editions, Captain Maury has gone much further, as the following extract shows: "Dr. Kane reported an open sea north of the parallel of 82°. To reach it his party crossed a barrier of ice 80 or 100 miles broad. . . . . Passing this ice-bound region by travelling north, he stood on the shores of an iceless sea, extending, in an unbroken sheet of water, as far as the eye could reach, towards the north pole. Its waves were dashing on the beach with the swell of a boundless ocean. The tides ebbed and flowed in it, and I apprehend that the tidal wave from the Atlantic can no more pass under this icy barrier to be propagated in seas beyond, than the vibrations of a musical string can pass with its notes a 'fret' upon which the musician has placed his finger. . . . . *These tides, therefore, must have been born in that cold sea, having their cradle about the North Pole, and we infer that most, if not all, the unexplored regions about the Pole are covered with deep water; for were this unexplored area mostly land, or shallow water, it could not give birth to regular tides.*"

It may be true, though it seems far from probable, that a vast arctic ocean occupies all the unexplored regions near the North Pole: but the "birth of tides in that cold sea" is certainly not established by the evidence adduced. Referring to Fig. 1, the reader will see, to the left of the central dark meridian, a strait, opening into the arctic regions within the eightieth parallel. It was here that Dr. Kane saw an open sea extending as far as the eye could reach to the north and north-east, with land (the most northerly yet seen) in the north-west. About as far to the right of the dark meridian, and just south of the eightieth parallel is the island of Spitzbergen; above, on the next dark meridian, is Nova Zembla; beyond that again, Liakhov Island, about as far from Behring's Strait (between Asia and America) on the Asiatic side as are the Parry Islands on the American side: and next to the Parry Islands is the strait from which we started. Now it is necessary for the purposes of Maury's argument, that it should be proved that there is no communication between the place reached by Dr. Kane and the Atlantic Ocean on the one side, or the Pacific Ocean (through Behring's Strait), on the other; in other words, that a land-locked or ice-bound ocean surrounds the

north pole, and that this ocean is so large that the attractions of the sun and moon on *different parts* of it are *sufficiently unequal* for the generation of tides.* Now it seems clear to me that even if the whole of the unexplored regions about the pole were covered by a deep land-locked ocean, yet no appreciable tides could be generated in an ocean so situated. But an arctic (land-locked) ocean must be much more contracted; for Captain Penny sailed on an open ocean between Liakhov Island and the Parry Islands, and Captain M'Clure proved that sea communication exists between Behring's Strait and the Parry Islands. Therefore any land or fixed ice locking the supposed arctic tidal ocean on this side must lie within 10° or 12° of the north pole. But a far stronger argument against Captain Maury's view may be derived from the results of Sir E. Parry's celebrated sledge excursion from Spitzbergen; for although Parry *saw* no open sea north of the eighty-first parallel, yet his expedition proved the *existence* of open sea as far north as the eighty-fifth parallel (at least); and therefore not only contracted to this extent the space within which a land-locked arctic ocean, if any exist, must be confined, but established the probability that open sea communication exists between the Atlantic and the point reached by Dr. Kane.

Let us see how these results may be deduced from the very circumstance which led to Parry's failure. Starting from Spitzbergen in the boats "Enterprise" and "Endeavour," the expedition sailed northwards for three days; but ice gradually gathering round them, they commenced a "boat and sledge" journey over a vast body of ice. After five weeks of labour, during which they travelled 290 miles northwards, they found that the distance from the starting-point was only 172 miles, the *southerly drift of the whole field of ice* over which they had been laboriously tracking their way having carried them back 118 miles! They had reached latitude 82¼° north, and they could see no sign of clear water in any direction. Now, remembering that an experienced arctic sailor can detect a "water-sky" long before open water can be seen, we may safely assume that the field over which they had travelled so far extended fully fifty miles farther north, and as far to the east and west. But this is not all. The point they had reached must have been 118 miles farther north when they started, since the whole field had travelled southwards by that amount. Therefore the open sea *communicating with the Atlantic*, on which their vast ice-ship was *floating freely*, had, when they started, extended at least 168 miles further north than latitude 82¼°, or further north than the eighty-fifth parallel (half way between

* It is clearly only by such inequality of attraction that tides can be generated in a land-locked polar sea.

Spitzbergen and the pole—see Fig. 1). It was precisely in this direction that Dr. Kane saw open water as far as the eye could reach—say twenty or thirty miles. The fact that so large a field, probably extending at least 100 miles from east to west, drifted freely for 118 miles, seems to prove that the sea on which it floated is deep, for otherwise islands or shallows would probably occur which would check the motion of large fields of floating ice. In fact, the voyages of Hudson (1607), Buchan and Franklin (1818), and Scoresby (1806) had sufficed to establish the probability that a vast offshoot of the Atlantic valley extends far towards the North Pole; and it was in this sea, in latitude 76° north, that Dr. Scoresby sounded to the depth of more than a mile and a half without finding bottom. It seems, therefore, far more probable (to say the least) that open sea communication exists in summer between the point reached by Dr. Kane and the great sea that washes the shores of Iceland and Spitzbergen—in other words, that Greenland is an island—than that the tides seen by Kane were born in a land-locked Arctic ocean, and had their cradle near the North Pole.

There are several purposes for which the projection of Fig. 2, independently of the advantage it possesses as an equigraphic projection, seems better suited than Mercator's. For instance, it would exhibit isothermal lines, lines of equal mean barometric pressure, and other such lines, more correctly both as respects their length, and as respects the distances between successive lines.

The projection of Fig. 3 has the advantage of simplicity of construction, and the map being divided into rectangular areas, it is easy to determine, by a few simple measurements, the areas of continents, countries, oceans, or seas.

Any other point might be adopted for the centre of the projection of Fig. 1, but the construction for the meridians and parallels would no longer be simple. The same remark applies to the projections of Figs. 2 and 3, if any other great circle than the equator is adopted for the central line; but of course any other meridian may be assumed as the central meridian without varying the construction.

One other point remains to be noticed. If the distances between successive meridians were uniformly diminished in any of these projections, so that Fig. 1 became a sector instead of a circle, and Figs. 2 and 3 were uniformly contracted horizontally on both sides of the central meridian, the projections would still be equigraphic. For special purposes such changes may be useful. Some arrangements of Fig. 1 may be noted in particular. If, instead of a complete circle, a semicircle be divided into thirty-six equal angles, the parallels remaining

unchanged, the spaces near the equator will have very nearly their true figure, and the distortion near the south pole will be diminished by one-half. This semicircle can be formed into a cone by bringing together the bounding radii (considering the semicircle as a sector), and the connection between different parts of the globe can thus be indicated as clearly as in Fig. 1. But a still better representation of the globe may be formed by taking two equal sectors of about three right angles, dividing each into thirty-six equal angles, describing parallels up to the equator, and drawing in the continent-outlines of the northern hemisphere in one sector, and of the southern hemisphere in the other. If the two sectors be formed into cones,* and these joined along the equator, an equigraphic representation of the globe on a double cone will be formed, the vertices being the poles. The construction of these figures, or of others formed in a similar manner from sectors of varying angles (or constructed on other projections), would form an interesting and instructive employment for the young geographer.

A work has lately been published, by a person writing under the pseudonym of "Parallax," in which it is gravely maintained that the earth is plane, and of a figure somewhat resembling Fig. 1, the parallels, however, being equidistant. The sun travels at a distance of about 4000 miles from the earth, in a circle of varying radius about the north pole as centre, being vertical over the equator at the equinoxes, and over the tropics of Cancer and Capricorn, in summer and winter respectively. The tides are caused by the motion of the earth, which floats (!) upon a bottomless ocean, and carries fire in its "hold" for the eventual destruction of its inhabitants. The moon has one luminous hemisphere, which, being presented in different proportions to the earth, produces the lunar phases, lunar eclipses being caused by an invisible semi-transparent satellite! The new system is supported, as is fit, by new principles—for instance, by a new law of perspective, "the law taught in our schools of art being contrary to everything seen in nature;" and a new law of projectiles, which, it appears, ascend diagonally in a straight line, and descend vertically. The author is described in the *Athenæum* as an enthusiast who goes about the country enforcing his views in lectures, and a hope is expressed that "he may make some converts," so that a "Wesleyan agitation may lead astronomers to defend the established" system more clearly than has yet been done!

* The vertical angle of either cone will be a right angle, if the angle of either sector is 254½°. In this case the axis of the double cone will be equal in length to the diameter of the equator, and the distortion will not be very great in any part of the projection. In the case first considered (of a semicircle) the vertical angle of the cone would be 60°.

Such a work is, of course, beneath criticism in these pages, but one remark on books of this kind may be useful to the young student. It will generally be found that for one page of the author's writing there are three of quotations, and that these are so ingeniously garbled, that their meaning is altogether perverted. Hence, if the student should feel perplexed by confident appeals to well-known authorities, it will be well for him to suspend his judgment till he has read the passages in the original. As instances of the necessity for this caution, an extract or two taken at random from the book mentioned will suffice. To prove that the parallel of Cape Horn is longer than the equator, "Parallax"* quotes Sir J. C. Ross as saying, "From near Cape Horn to Port Philip (Melbourne) the distance is 9000 miles;" therefore, these two places being 143° apart, the length of the parallel of Cape Horn is 22,657 *nautical* miles. It happens, however, that Captain Ross is quoting the words of a landsman, so that the miles are presumably statute miles; and that reference is made to the course of a bottle, which travelled in an *easterly* direction, and therefore passed over 217° instead of 143°, Ross himself adding that the bottle must have passed Kerguelen Island. Again, the author, wishing to prove that the Pole Star can be seen *as far south as the tropic of Capricorn*, quotes the *Times* of May 13, 1862, in which, under "Naval and Military Intelligence," it is stated that Captain Wilkins, of the troop-ship "Earl Grey," saw the Southern Cross and the Pole Star at midnight, April 19th, in 23° 53′ lat., and 35° 46′ long. Here again the evidence would be good, were it not that Captain Wilkins was *north of the tropic of Cancer* on the 19th of April,† having left St. Helena on March 18th (homeward bound from the Cape), and sighted the "Lizard" on May 10th; therefore (as usual when no doubt can arise) the denomination of the latitude, as of the longitude, was omitted in the report.

An examination of this sort affords a ready means of determining whether the author of such a work is simply ignorant, or whether (in addition) he is practising on the assumed ignorance and credulity of his readers.

* From παραλλάσσω, "*to alter a little*, esp. *for the worse*."—Liddell and Scott.

† The Southern Cross had passed the meridian about an hour and a half before the time of observation, and the whole of the constellation was still several degrees above the horizon.

SCHULTZE'S ARTIFICIAL DIATOMS.

BY HENRY SLACK, F.G.S.,

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THE *Quarterly Journal of Microscopical Science* for April, 1863, contained an abstract of a paper by Professor Max Schultze on "the structure of the valves of diatoms, as compared with siliceous pellicles produced by the decomposition of fluosilicic acid in moist air." I do not propose to enter upon any discussion of the markings of diatom valves, but to suggest to amateur microscopists, who do not appear to have taken much notice of the paper in question, some very curious and interesting experiments.

The numerous readers of the INTELLECTUAL OBSERVER who are well acquainted with chemistry will excuse my beginning with a description of fluoride of silicon, and the mode of obtaining it. Fluorine is put down in the chemist's list of simple substances—that is, of substances which have not been decomposed. It is not known in a free state, but from its behaviour in compounds it is usually grouped with chlorine, iodine, and bromine. "These," says Dr. Apjohn, speaking of the group, "have numerous points of resemblance, being all electro-negative in a high degree, bearing strong affinities for the other metalloids and the metals, and forming with them chemical compounds of great interest and importance, analogous in composition, and generally possessed of very similar properties."

The well-known and beautiful mineral fluor spar is a compound of fluorine and calcium, the metallic basis of lime. If we take some fluor spar, or fluoride of calcium, and pour sulphuric acid upon it, hydrofluoric acid, a compound of hydrogen and fluorine escapes. This substance is a rapid solvent of glass, and is used in etching on that material. If we add to the powdered fluor spar powdered glass, or clean white sand chiefly composed of silex, part of the silex is taken up by the fluoric acid at the moment of its formation, and the result is a gas, which makes white cloudy fumes on coming into contact with air containing moisture. Silica, found pure in clear quartz, and nearly so in flints, is a compound of silicon and oxygen, and is also called *silicic acid*. Hence the compound of fluoric acid and silicic acid is called fluoride of silicon, or in more recent nomenclature, "silicic fluoride."

When silicic fluoride comes into contact with water, it is decomposed, and deposits one-third of its silica, the other

two-thirds remaining in combination with the fluorine and hydrogen. The silica in this decomposition will be deposited differently according to the circumstances of the case. To make Schultze's artificial diatoms the process should go on slowly and gradually. For this purpose I have found the following arrangement very convenient. Take two six-ounce and moderately wide-mouthed bottles, and put into one a teaspoonful of powdered fluor spar, and about the same quantity of clean silver sand; pour over it to the depth of an inch sulphuric acid, and stir up the mixture with a glass rod. Then take a tuft of cotton wool pulled out loosely, wet it, and put it as a *loose* stopper in the mouth of the bottle. Fill the second bottle with plain water; take some lamp cotton as thick as a pencil; drop one end into the water, leaving it long enough to go to the bottom of the bottle. Place the two bottles side by side where they will not be disturbed, and put the other end of the lamp cotton on to the top of the cotton stopper in the bottle containing the chemical ingredients. Fluoride of silicon, or silicic fluoride, will slowly rise from the mixture, and on coming into contact with the wet cotton, will deposit a portion of its silica in vesicular form. The lamp cotton will, by capillary action, carry water from the bottle in which one end is immersed to the cotton stopper, and keep it constantly moist.

The whole arrangement should be left undisturbed for a day, when the cotton stopper may be cautiously removed, and the white deposit upon its threads delicately swept on to a piece of blotting-paper. When it is quite dry it is ready for examination. The cotton may be replaced, and left for two or three days or more, when a second crop can be removed.

Care must be taken, in examining this deposit, not to let the moisture it contains come into contact with object-glasses, or any part of the microscope, as it corrodes glass with great rapidity. When quite dry it may be viewed under a low power, as an opaque object, and a general notion of the mode of deposition will be obtained. Some of it should then be gently crushed on a slide, under a thin covering glass, which may be fastened down by a little cement at the edges. This should be viewed with a quarter or higher powers, when some of the broken vesicles will look amazingly like fragments of diatom valves. In the number of the *Quarterly Journal of Microscopical Science*, to which allusion has been made, several diagrams are given of the patterns Professor Schultze obtained, and all of them, and many more will be easily found by following the directions given.

I will describe a few in one slide as viewed under a magnification of 1000 linear. Some, formed most quickly, are

irregular, while the better specimens are quite regular, though diversified. Here I find one fragment exhibiting round bosses, appearing, under the magnification specified, one-tenth of an inch in diameter, and regularly grouped, the interspaces being larger than the bosses. In another fragment little nodules or bosses, about one fifteen-thousandth of an inch in diameter, are widely scattered, and in another similar little bosses, about one twenty-thousandth of an inch in diameter, are closely and symmetrically arranged. In some specimens a number of the larger bosses are grouped in symmetrical patterns, and each one is surrounded by much smaller protuberances, equally symmetrical. These are very elegant objects. The slide also contains tubular fragments of vesicles, like sausage skins, with here a twist, and there a constriction. Some of these are quite plain, while others are elegantly marked. Many of the markings on the portions of vesicles are so delicate as to look very fine and small even under the magnification of one thousand linear.

In some cases large hemispherical bosses, closely grouped together at the base, exhibit, when in focus, a hexagonal appearance at the lines of contact, and a concentric structure is visible in many under appropriate illumination. By employing an achromatic condenser and a central stop, some—at a certain focus—have the aspect of groups of eyes. First comes a luminous white circle, then a dark one, like an iris, and in the centre a bright spot like a pupil.

Close examination indicates that many of the little bosses which look like hemispheres are in reality composite, and it is common to find little mammillæ, or rounded projections, on the top of the bosses. In some cases the form of the bosses is irregular, and many will be seen composed of two or more individuals stuck together.

In the paper of Max Schultze that suggested these experiments, it is said that these patterns are not due to a crystalline structure, and several reasons are adduced for this belief. It is, however, certain that crystalline deposits in the form of needles may be found in the bottles in which the hydrofluosilicic acid is prepared, and miniature quartz crystals resulted from the following variation of the experiment :—

Some fluor spar sand and sulphuric acid was placed in a Florence flask, and through a cork inserted in its mouth a bent tube was inserted. The free end of this tube was immersed in a little mercury contained in a small evaporating dish, and as the gas escaped through the liquid metal, it was allowed to blow little bubbles, or vesicles, of white of egg, a layer of which was placed over the mercury. These were permitted to dry and harden, and when the crushed fragments were

examined numerous quartz crystals were observed, rhombohedra and six-sided prisms, many imperfect, and some adherent, so as to form crosses.

In another experiment made by the writer, a little mercury was put into a test tube, and above it about three inches of white of egg. The tube discharging the silicic fluoride gas was immersed in the mercury, and as the gas rose, it passed through the white of egg, speedily coagulating it to the consistence of thick clotted cream. This creamy mass was then dried, and ignited in a platina crucible over a Bünsen burner, until the organic matter was destroyed. The residue—very small in quantity—was found to consist of silica, in a vesicular state. In some cases the walls of the vesicles were so thin as to give rainbow colours when light was thrown on them, or slantingly through them. No crystals were formed in this experiment.

REGISTRATION OF COINS.

Those who are curious in regard to such comparatively small matters, and numismatists generally, will have observed that all the gold and silver coins above the value of the threepenny piece issued from the British Mint during the last two years have one or more small numerical figures imprinted upon their surfaces, immediately over the date. The object of this rather singular arrangement has given rise to a considerable amount of speculation, and many letters of inquiry have, we believe, been addressed to the Mint authorities as to the real motive of the innovation. Having ourselves obtained, from the best source, the true reason assigned for stamping numbers on the coins of the realm, we have this month the satisfaction of conveying a similar amount of enlightenment to the public.

It is done with a view to identifying the particular die by which each individual piece of money was struck, the particular press at which the latter received its impressions, the day on which it came into existence, and the name of the press-attendant under whose agency it was born. Thus, if a defective coin, which had escaped the vigilant and scrutinizing eye of the examiner at the Mint, and passed out into the channels of general circulation, were subsequently discovered —no matter how long after its issue—it would be possible, by a reference to Mint records, to establish its identity, and to fix the responsibility for its defect upon the unhappy wight

who managed the machine which stamped it into being. What the punishment attached to the offence may be we know not, for that, no doubt, would be made to depend upon the presence or absence of extenuating circumstances, and the leniency or otherwise of Mint officials.

The mode of effecting the registration we shall now endeavour to explain—one kind of coin being taken as an illustration of the rule applied to the whole of the denominations of money systematically numbered. Let it be supposed, for example, that the Mint is about to inaugurate a coinage of sovereigns for the year 1866, and that it has been determined to establish in perpetuity, and by official documentary evidence, the birthday of each individual coin—the date itself notifying the *year* of its production. Then the first step after the reception of the precious metal from the Bank of England, will be the preparation of dies. Each of these, after receiving its impression at the hands of the Die Multiplier, and while yet in its annealed and plastic state, is returned to the Engraver for numbering. On the first die which reaches him he imprints, by means of punch and hammer, the figure *one;* on the second, figure *two;* on the third, figure *three;* on the fourth, *four;* and so on up to twenty, thirty, or more, as it may happen. The whole are afterwards hardened, tempered, and polished, and then transmitted to the coin-stamping room. Here they are received by the officer in charge. Under his direction, die No. 1 will be affixed, with its companion obverse, say to press No. 4, at nine in the morning, on the 16th of July; die No. 2 to press No. 5; No. 3 to press No. 6, and so on—R. M.; J. S.; W. R.; T. H., etc., being the initials of the respective youths attending the presses. All these facts are recorded by the Superintendent of the Department on a tabular form provided for the purpose. The presses are then made to commence their money-making careers for the day; and, blanks of gold being supplied *ad libitum*, they continue, so long as the dies remain uninjured, to give forth numbered sovereigns in large quantities. It is possible, indeed, that the numbers on the dies may be reproduced to the extent of 25,000 or 30,000 on the surfaces of the coins yielded by each press. When either of the dies fails by cracking or becoming otherwise defaced, it is at once removed, and its place is filled by another, the like particulars in reference to which are duly entered, as before, in the journal of registration.

As a general rule, no pair of dies lasts longer than a single day in a Mint coining-machine, and it may be fairly supposed that those of which we have spoken as engaged in stamping gold coins on the suppositious 16th instant, will not outlive

that period. They will therefore all be removed at its close, their vacant positions being occupied by others bearing consecutive numbers, and of which the same careful notes will be taken. Thus day after day throughout the remainder of the year the work of numbering, registering, and stamping may go on, and the birth, parentage, and education of each piece of money be accurately recorded. The coinage of every year is made distinctly identifiable by the date, and therefore the first die for each denomination of coin used in each year is marked as No. 1, and *sequitur* in due order.

Such are the arrangements for effecting the registration of the coinage of the realm as at present put in force at Her Majesty's Mint—whether usefully so or not is another question. To us there seems to be some practical objections to the process, however in theory it may seem ingenious and serviceable. Surely it must be very difficult for a press-boy—unless Argus-eyed—to examine with any care the surfaces of pieces of money which are struck off from his machine at the rate of seventy per minute, and which accumulate with astounding rapidity in the catch-pan below, he having the press to feed and keep in order during its working. Equally puzzling must be the task of examining the dies between each stroke of the press! Would it be just to punish or blame a youth for the non-fulfilment of an impossible duty? Great care of course is necessary in the performance of the delicate task of creating sovereigns or shillings, but it can only be effectually exercised by a judicious division of labour. No one person can be justly made responsible for the commission of a fault, unless he have the power to prevent its occurrence. As in printing the sheets of periodicals and newspapers, a certain percentage of them is damaged and wasted, so is it in the rapid stamping of coins by steam machinery. The greatest diligence on the part of press attendants will not prevent this inevitable result, and the true remedy for it lies in the subsequent elimination of soiled or defective specimens by the aid of the searching eye and quick hand of a numismatic critic or inspector of coins—at least, that is our deliberate opinion. Herein lies one of the weak points pertaining to the system of coin numbering. Outside the walls of the Mint that system can be of no service whatever. It certainly is of little moment to the public whether the coins jingling merrily in their pockets, or glistening cheerfully in their *porte-monnaies*, were struck off in the month of May, June, or August, in the forenoon or afternoon of any particular day, or whether the machine which communicated their images and superscriptions were, for the time being, under the care of Master Tom Stiles or Master Jack Nokes.

That the coinage of the realm should be as near perfection

as it can be made, is true, but we fail to see that the addition of two or three figures to the devices which so richly ornament the various denominations, advances it one stage nearer that point, or answers any really useful end.

COTTA ON ROCKS.*

Professor Cotta tells us in a preface that the present English version of his work on rocks may be regarded as its third edition, the modifications and alterations having all been made with his concurrence.

It is a very valuable work, and although we could have wished that a more elaborate account had been given of chemical researches and synthetical experiments, elucidating the probable origin of many rocks, such a course would have greatly extended the bulk of the volume, which is now compact enough and cheap enough to answer the purpose of a general manual for students.

After some chapters on the minerals entering into the composition of rocks,† Professor Cotta enters upon the question of *texture*, and points out that all rocks may be divided into two principal classes, *granular* and *compact*. "The word granular is, however, usually only applied when the different mineral parts are all of a granular shape, of nearly the same size, and are crystallized into each other." Rocks composed of grains, pebbles, or fragments mechanically cemented together, may be *arenaceous*, as sandstones; *conglomerates*, in which more or less rounded masses much bigger than grains, are caused to adhere by some natural mortar or cement; or *breccias*, in which the fragments are angular. "The term *compact* is usually only applied to a rock when its particles adhere firmly and closely together (without being fused into one mass like glass)." A loose friable condition is termed *earthy*, and a fused one *vitreous*, or *opalescent*, as the properties designated by those terms may be exhibited. Every rock, according to Professor Cotta's nomenclature, must be either *granular* or *compact*, using both terms in a wide sense. The *granular series* may be any rocks, fine, or coarse, in which the individual component parts are recognizable, while in *compact*

* *Rocks Classified and Described:* A Treatise on Lithology, by Bernhard von Cotta. An English Edition by Philip Henry Lawrence, with English, German, and French Synonymes. Revised by the author. Longmans.

† It is necessary to remind readers unacquainted with geology that in technical use the word *rock* comprehends all sorts of natural formation.

rocks no such distinction of individual parts can be observed. The texture of a rock is termed *porphyritic*, when distinct crystals or crystalline particles are distributed through an otherwise compact principal mass or matrix. *Schistose* (foliated), *slaty* (cleaved), *shaly* (laminated), and *fissile* are terms expressive of different sorts of parallel structure, and will be easily understood. Mr. Jukes says, "When we wish to be precise we speak of the *foliation* of schist, the *cleavage* of slate, and the *lamination* of shale."

With reference to slaty cleavage Professor Cotta dissents from Poulet Scrope's conjecture that it may have arisen from friction of some kind, nor does he agree with those who ascribe it to a crystalline action, but he accepts the views of Sharpe, Haughton, Sorby, and Tyndall, that when not identical with stratification, it has, in most cases, been caused by pressure at right angles to the cleavage plane applied to the rock during or after its formation.

To give definite meanings to *vesicular*, *scoriaceous*, and *pumiceous*, the first will be restricted to cases in which the vesicles are isolated; the second to instances in which they occupy a space equal to the solid part of the rock; and the third to cases in which the hollow parts predominate over the solid. "A rock is said to be *amygdaloidal* when the vesicular cavities are filled either entirely or in part with new mineral substances. The filling in of these cavities is always a process subsequent to the formation of the rock." The Professor adds, "We infer from all the attendant circumstances that the formation of those amygdaloids must have been a very slow process. . . . Hence we may explain the fact that the most recent of all igneous rocks, the lavas, although they are very often vesicular, are never amygdaloid. Hence the frequency and completeness of the filling up of the cavities increases almost in direct ratio with the age of the rock." It is observed that igneous rocks rich in silica are not only less frequently vesicular, but that when the vesicles occur they are less frequently filled up, "which probably arises from their containing fewer soluble substances adapted to the formation of amygdaloids, in particular less lime and magnesia." *Oolitic* texture belongs to certain limestones and iron stones, formed by the conglomeration of rounded or egg shaped bodies which may be very small, or like peas (*pisolitic*) in pea stone. The term *nodular* needs no explanation, and Mr. Dana's term *spherulitic* is applied to some igneous rocks exhibiting pearl-like globules.

Rocks are placed in three great divisions—igneous, metamorphic crystalline schists, and sedimentary. It is of those in the first division only that we now propose to speak. The igneous rocks may be *volcanic*—that is, erupted rocks, which

have manifestly been in a state of fusion, and which have solidified at the surface of the earth—or *plutonic*. In the latter case, "their former state of fusion is not so clearly evident; indeed, we occasionally find their composition, their bedding, or their relative position with other formations, in apparent contradiction to their assumed origin. It is supposed that these became solid at a considerable depth, some of them possibly having been poured out in a state of fusion, like lava, but in the interior of the earth without reaching the surface, and consequently that their consolidation took place under very high pressure, and more slowly than in the case of the volcanic rocks."

Professor Cotta accepts the division of igneous into *basic* and *acidic*, as referring to important facts, but he rejects the special theories connected therewith put forth by Von Richthofen and Durochet,* and somewhat hastily adopted by Professor Haughton in his *Manual of Geology*. *Basic* rocks are poor in silica; *acidic* rocks rich in that important compound. Basic rocks contain from forty-five to fifty per cent. of silica, acidic rocks from sixty to eighty. "But," as the Professor remarks, "the limits are sometimes overstepped on either side, and there are igneous rocks which we cannot, with mere reference to their chemical composition, reckon in either group, and which in fact entirely fill up and annihilate the assumed gap between the two in respect of the content of silica." The acidic rocks, or those containing the greatest amount of silica, are specifically lighter than the basic rocks; and hence arose the notion that the distinction between them may be dated back to the time when the earth's crust began to solidify, and the lightest portion of the fused matter, being nearest to the surface, cooled first. This may be so, but facts do not justify the inference that has been drawn by some geologists, that all acidic rocks are older than the basic. Professor Cotta tells us that "every geological age has produced acidic as well as basic — specifically light, and specifically heavy, igneous rocks. When syenite and granite occur together, it is most usually the case that the basic syenite is older than the acidic granite. The basic porphyries in the Thuringian Forest and the Erzgebirge are, on the average, older than the acidic porphyries, which belong to the same great period. The trachytic porphyries belong to the most acidic, and yet frequently to the most recent eruptive rocks."

The following passage is highly important:—"Neverthe-

* Chemists speak of salts as composed of *acids* united to *bases*. The term *basic* indicates a predominance of the base, while the contrary is meant by *acidic*. Silica is reckoned among the acids, being composed of silicon and oxygen, and forming salts with bases from lime, etc.

less, we are not of opinion that the theory of an arrangement of substances, according to their specific gravity, should be disregarded as entirely unworthy of serious attention. Specific gravity may and probably has had a certain influence in the first arrangement of rock masses; and if we are now unable to trace a consistent arrangement deducible from the laws of specific gravity, it may be only because those traces have, to a certain extent, been subsequently effaced by other circumstances which we have not yet discovered. A primary crust formed by cooling, and the first sedimentary deposits resulting from the decay of that first crust, may well have been preeminently rich in silica; more especially if, at the time of those sedimentary deposits, animal life had not begun to act on the calcareous water, to cause a re-deposit of the dissolved lime in large masses. If this primary portion of the earth's crust should, at a later date, have been subjected to a second process of fusion under high pressure, at a considerable depth, it may have become partially eruptive, and have produced recent rocks very rich in silica, and of a very uniform chemical composition. We may, in fact, reasoning from analogy to the meteoric stones, which represent to us the small planetary bodies of our solar system, believe the aggregate of the earth's mass to be far more strongly basic than that part of it which is open to our observation."

In applying the term "igneous" to rocks, Professor Cotta by no means excludes, in all cases, the conjoint action of water, and he accepts the appellation of "hydro-igneous" as applicable to such cases. Upon the moot question of the formation of granite, he does not consider the arguments against its igneous origin as conclusive. The different degrees of fusibility of felspar, quartz, and mica, when taken separately, he contends may be much modified by their mixture. He refers to experiments of Durochet to show that in the compact rock petrosilex, whose composition is often the same as that of granite, the quartz is found to be as readily fusible as felspar alone, and he concludes that when such a mass cooled, the quartz would not necessarily solidify first, and separate itself from the felspar, and he fortifies his opinion by other experiments of Bunsen, who has shown that the melting and solidifying points of a mineral, taken singly, by no means determine those of an intimate compound, or alloy of such minerals with other minerals. With regard to the presence of water in granite, he refers to Daubrée's having shown that under great pressure, at a high degree of temperature, water may be made to combine chemically with mineral matter.

Although volcanic action must, in all probability have been violent and frequent in early ages of the earth's formation,

the volcanic outpourings that we are acquainted with are "of comparatively recent date, and probably no ancient ones are now existing: for the most part they have decayed away." Enormous periods must have elapsed since the solidification of the earth's crust took place, and the conclusion of Professor Cotta is one that has been frequently advocated in our pages, that "there seems nothing left for us in the present state of our knowledge but to assume that the greater part of the first crust, having become very thickly covered with deposits, has been gradually re-melted, and become eruptive, perhaps in the form of granite. There is indeed no reason why the same fate should not have been shared by the oldest rocks of deposit, and thus it may be that the chronological starting point of geological development has been frequently effaced, and become altogether uncertain."

Without following Professor Cotta through other portions of his treatise, we may express a high opinion of its value, and also congratulate his translator and editor on the efficient performance of his task.

ANIMAL FORCE AND ANIMAL FOOD.

BY J. BROUGHTON, B.SC.

Until the last twenty years, it was generally held that the phenomena of animal life presented a totally different set of conditions to those occurring among lifeless matter. The invariability of the action of the various forces which are constantly producing changes in the inanimate world, was supposed to be completely altered by the presence of *life*. This alteration in the ordinary sequence of physical causes and effects was attributed to the operation of an occult power, to which the name of vital force was given. This agent was accordingly supposed to exert a sort of directive agency, by means of which the ordinary operations of the forces of matter were suspended or modified, and effects were produced of a different character to those observed out of animate bodies. It was also to this agent that the power of voluntary motion, and the exertion of internal and external mechanical forces, was more particularly ascribed, this power of voluntary motion being the property which forms the main distinction between an animal and a plant. It is not, indeed, strange, that this remarkable faculty we possess of making our movements obey our will, or of ex-

erting upon external objects the force of our bodies, should have furnished a subject for the wonder of all thoughtful minds, and that a special cause should have been assumed by way of explanation. Nor, indeed, is the wonder at all diminished at the present time by our better understanding of the true causes, and of the modes in which they operate.

Of late years, the special character of the vital force has found but little support from the laborious results of those engaged in investigating the processes that take place in the bodies of animals. Indeed, it is apparent at first sight that the physical forces affect living bodies just as they do everything else. The weight of all the parts shows the influence of the force of gravity; and the laws of hydrodynamics, of heat, and of light, find rather favourable illustrations among the various internal phenomena. The same is found to be equally the case in the chemical processes of digestion and assimilation, which, as far as they are known, do not essentially differ from the similar processes that can be carried on without the body. Again, the bodies of animals have often been compared to furnaces, of which food forms the fuel. The latter has to be supplied at tolerably regular intervals, varying according to the nature of the animal, and the construction of his internal apparatus of assimilation, and is there made to undergo various changes which finally result in its combustion. Notwithstanding that this comparison is a sufficiently crude and inaccurate one, it expresses the gross results tolerably correctly. As far as the final result of the various metamorphoses of the food are concerned, it is really consumed in the body. Both in the fuel of the furnace and the food of the body, the carbon is combined with oxygen to form carbonic acid, and with the hydrogen to form water; while in both cases some of the fuel escapes consumption, and is expelled along with the incombustible salts. But, on the other hand, while the furnace allows the nitrogen of the fuel to escape in an uncombined form, the body excretes it in the form of urea, a crystalline substance peculiar to the animal body. If we push the analogy still further, and determine the heat produced by this process of internal oxidation, we find the comparison still to hold good. Not only is heat given out in both cases, but it is actually the same in amount. The experiments of Dulong and Depretz have shown that the same amount of heat is given out from the body of a living animal as its food would produce when submitted to combustion in oxygen.

In 1842, Liebig, by considering the nature of the tissues and the various phenomena of nutrition, respiration, and motion occurring therein, and applying the known laws of chemistry to their explanation, showed the comparative simplicity which

really underlies the complexity of most physiological processes. In his great work on *Animal Chemistry*, he showed the identity in chemical composition between the muscular substance and the nitrogenous constituents of the food. He also, as is well known, divides the various kinds of food into two great classes, namely, those which contain nitrogen, and serve for the building up of the muscular tissues, and those destitute of nitrogen, as starch, fat, etc., whose use is limited to the production of animal heat. These two classes he named flesh-formers and heat-givers respectively. In the same work he considers fully the subject of animal motion. Respecting this he teaches that the source of the muscular force of animals is the combustion of the living muscles by means of the oxygen conveyed to them by the blood, and that consequently every motion, however slight, is the cause of the destruction of a certain amount of muscle, and the liberation of its (so-called) vital force.*

The final product of this destruction of the muscular substance is urea, which passes into the blood, and is extracted from thence by the kidneys. Therefore, if the above explanation be true, the amount of urea given out should indicate exactly how much muscle is consumed; and a man working hard ought to produce much more urea than one at rest, since, by reason of the great expenditure of force, a larger amount of muscle is burnt. The experimental proof of this was, however, very difficult to give, since the amount of urea excreted also varies, to a certain extent, with the amount of "flesh-formers" supplied in the diet. Notwithstanding this failure of direct evidence, the explanation of Liebig has been generally held to be the true one, and up to the present time the source of animal force has been believed to be the oxidation of the living muscles.

But of late years the subject of the muscular movements of animals has been placed in a new light by the now well-known relations of the forces of heat and mechanical energy. By the doctrine of the conservation of force, we know that, whatever may be the proximate source of the force of the muscles, it must be attended with a disappearance of heat from the body. It is from considerations founded on this equivalency of heat and mechanical force that much of our more recently acquired knowledge of animal dynamics is derived. Thus Helmholtz has shown that, considered simply in the light of a machine for the conversion of heat into force, the human body surpasses the best steam-engine that has ever been constructed. Of the total heat given out by the combustion of the food, a man can make a fifth available in the form of actual work, while it has never been found possible to construct a steam-engine that

* *Animal Chemistry*, second edition, p. 220, *et seq.*

could utilize more than a ninth of the energy of the fuel burnt under the boiler.

But in addition to this external work, the body has constantly to perform a vast amount of work in order to sustain the life. There is the blood to be kept circulating and urged through the lungs and capillaries; the chest and diaphragm have to be raised for the purpose of breathing; digestion has to be carried on and the body kept erect—all these consuming energy. It has been determined that the heart, contracting at the rate of seventy-five pulsations to the minute during the twenty-four hours, performs an amount of work equivalent to raising a hundred-weight to the height of 4463 feet. The work of breathing has been estimated by Fick to be about equal to raising the same weight to the height of 703 feet. The other sources of internal work have not yet been estimated, but it is quite evident that the amount of labour the laziest of us perform is very great.

It is indeed of the greatest importance to physiology that the real source of muscular power should be discovered. If it be derived, as Liebig and most subsequent physiologists have believed, from the living muscles, then it naturally follows that the main food of a working man should be those substances which alone can produce muscle, and should consist of flesh-formers. The question is to determine whether the muscle is merely the apparatus by which animal motion is produced, or whether it furnishes both the apparatus and the force to work it. The difficulties in the way of a resolution of this question are very considerable, and it is only lately that it has been attacked by direct experiment. The recent researches of Dr. E. Smith and the Rev. Prof. Haughton appear, however, to throw considerable doubt on the received theory; and within the last few months a crucial experiment has been made in Switzerland by Drs. Fick and Wislicenus, Professors of Physiology and Chemistry at Zurich University. Still more lately, additional experimental data have been furnished by Professor Frankland, who gave, on the 8th of June last, a complete discussion of the whole question at the Royal Institution.

In order to solve this problem by experiment, there are three things necessary to be determined. First, the amount of force or energy generated by the oxidation of a given amount of muscle in the body; secondly, the amount of mechanical force exercised by the muscles of the body during a given time; thirdly, the quantity of muscle oxidised in the body during the same time.

Now it follows that if the amount of mechanical force exercised by the muscles be greater than the amount of their substance oxidised could possibly furnish, then it is evident that

the force of the muscles is not exclusively derived from their own substance.

When muscle is consumed in the body, the whole of its nitrogen appears in the urine, principally in the form of urea. Hence it follows that the amount of energy derived from the oxidation of muscle in the body will be expressed by the heat of combustion of the muscle itself, *minus* the heat of combustion of that amount of urea which the muscle would furnish when consumed in the body. This difference of heats was determined by Frankland, who found that to convert one gramme of dry muscle into urea, as much heat was evolved as would, when converted into mechanical force, be sufficient to raise a hundred-weight to the height of 132 feet.

The second of the required data—viz., the actual work performed in a given time by the muscles—was ingeniously determined by Fick and Wislicenus by the elevation of the body itself. For this purpose they ascended the Faulhorn, a mountain of the Bernese Alps, 6560 feet high, near the lake of Brienz, whose regular slopes rendered it well adapted for their experiment. The height of the mountain, multiplied by the weight of the body of each experimenter, gave the amount of external work performed, and to this was added the estimated internal work of the circulation and respiration.

The third datum—the amount of muscle consumed—was given as a maximum by the amount of nitrogen excreted by the kidneys. This amount being determined by analysis, the amount of muscle is readily calculated, since every 15·6 parts of nitrogen indicate 100 parts of muscle destroyed. The excreted nitrogen was determined in the experiments of Fick and Wislicenus with every possible care; and in order that there might be no source of loss, the amount excreted for six hours after the ascent was taken into account.

As a final result of their investigations, they found that the muscle consumed, even with the most liberal allowance for all possible chance of error, would not account for the work performed. Even under the most favourable interpretation, and neglecting all the internal and external work that could not be accurately measured, *it was found that the combustion of the muscles themselves would not account for a third of the work performed.*

Some time ago Dr. E. Smith made some experiments of a similar nature upon prisoners working at the treadmill, which, rightly interpreted, point to the same result. The treadmill is found to be an extremely convenient instrument for physiological investigations of this kind, since it permits the accurate registration of the work performed, and also ensures regularity of performance. The experiments were made upon four

prisoners, who made a total ascent of 1·432 miles a day, an amount of work far less than that taken for amusement by mountain tourists. The actual muscle consumed being determined in the same manner as in the latter experiment of the German professors, it was found that the combustion of the muscle was sufficient to account for but three-fifths of the work performed, although the labour was comparatively light. It was also a significant fact that the amount of urea given out was not increased by the exercise. This was in agreement with previous experiments of Draper, Speck, and Lehmann, and, taken in connection with the foregoing, points to the conclusion that the oxidation of the muscle contributes at the utmost but a very small proportion of the muscular force. The destruction of the muscle is really due to those processes of change and death, to which nearly all the tissues of the body are (as is well known) successively subject.

Other experiments made by Haughton on military prisoners at shot-drill also show the great excess of the work actually performed over that which could be furnished by the destruction of muscle, but enough has been adduced to show that we must look elsewhere for the source of that power of which the muscles are but the agents.

Whence comes, then, this strange muscular force which we exert at will, and are able to combine and direct in so wonderful a manner? If it be not furnished by the muscles, where is the source of its supply? To this inquiry the answer is clear and definite. It is the food, as assimilated in the blood, and the combustion of the various articles of diet, both those hitherto called heat-givers, as well as the flesh-formers, that furnish the muscles with their power to contract. This important result is clearly shown by the researches of Dr. E. Smith, who finds the combustion of *carbon* in the body varies according to the amount of work the body performs. This fact, indicated by the amount of carbonic acid exhaled, is evident from the following table:—

	Carbonic acid evolved per hour.	
During sleep	19.2	grammes
Before sleep, but after lying for several hours	23.0	„
Walking, at two miles per hour . .	73.6	„
Walking, at three miles per hour .	100.4	„
Upon the treadwheel, ascending one-third mile per hour	175.0	„

Here, then, in the energy stored up in the carbon and

hydrogen of the food, we find the origin of the work of the field labourer and the navvy—the power that raises the sky-lark, and that which enables the squirrel to leap from tree to tree. The combustible and the oxygen co-exist side by side in the blood, and are thus carried through the muscles which furnish the instrument. The nervous agent (so to speak) fires the train, or pulls the trigger, and the still energy of the combustible immediately takes the active form of motion.

These views of the origin of muscular force suggest profound changes in the diet necessary to persons engaged in bodily labour. It is known, by the experiments of Savory on rats, that the purely albuminous constituents of food, in the absence of "heat-givers," will enable the body to perform all its necessary internal work; but it is very improbable that such is to any extent the function of nitrogenous food. The use of the latter is doubtless (as shown long ago by Liebig), that of providing fresh muscular tissue to replace that which is constantly undergoing waste and decay. It is estimated that this would be furnished by $3\frac{3}{4}$ oz. of dry albumen every twenty-four hours, and this amount being supplied, the remainder of the food necessary to supply the body with its working fuel may be either of the starchy or fatty classes. In fact, articles of food, such as animal flesh, are under positive disadvantages as working foods, since they are *incompletely* burnt in the body, and consequently all the energy they contain is not available. The urea they produce though a waste product is really a combustible substance. It is on this account also that gelatin, from its richness in nitrogen, is theoretically the least economical. But the fats, sugar, etc., are completely consumed in the body, and even more perfectly than would happen were they thrown into an ordinary fire.

Frankland has determined the amount of force capable of being given out by various articles of food, by noting the rise of temperature produced by deflagrating known weights with chlorate of potash under water. From the results thus obtained, the following table was calculated, showing the amount of force developed by one gramme of various foods when consumed *in the body*. This is expressed in meter-kilogrammes, or the force necessary to raise a kilogramme (2.4lbs.) to the height of a meter (3.28 feet). The food is in its ordinary condition, and the per centage of water it contains is appended.

Actual energy developed by various articles of food when consumed in the body:—

Name of Food.	Metre-kilogrammes.	Per Centage of Water.
Cheshire cheese	1908	24
Bread	1201	44
Milk	266	87
Potatoes	482	73
Apples	315	82
Oatmeal	1798	—
Pea meal	1765	—
Flour	1797	—
Rice	1760	—
Arrowroot	1901	—
Mackerel flesh	738	70.5
Lean beef	623	70.5
Beef Fat	4113	—
White of egg	266	86.3
Isinglass	1700	—
Hard-boiled egg	1030	62.9
Carrots	243	86
Cabbage	198	88.5
Cocoa nibs	3149	—
Cod-liver oil	4127	—
Lump sugar	1800	—
Butter	3331	—

The above numbers show, in a very striking degree, the advantages, as a source of animal force, that the dry, farinaceous cereals possess over the animal foods. This is, however, principally owing to the amount of water the latter contain; for when dry, they have somewhat the advantage over the cereals. But it will be observed that both are enormously surpassed by the fats and substances which contain fat, such as cocoa or cheese. The superiority of cod-liver oil as a source of force to every other substance is also very remarkable, and justifies its great use in medicine. Indeed, the condensed form of nourishment afforded by the fats has long been known. The chamois hunters, who have to undergo continued and severe exertion among the peaks and glaciers of the Alps, are accustomed to take with them as provisions nothing but fat and sugar. They say that these substances are more nourishing than meat, for they have learnt by experience the rich supply of force-producing matter these substances afford.

It will be observed that some vegetables also have very low force value, on account of the amount of water they contain. Indeed, apples, cabbage, etc., almost as much deserve the name of drinks as milk or beer. But the different values of the various articles of diet becomes more evident when they

are stated in an economical form, with the cost attached, as in the following table:—

Weight and cost of various articles of food required to be consumed in the body, in order to raise 140 *pounds to the height of* 10·000 *feet.*

External work = $\frac{1}{5}$ of actual energy.

Name of Food.	Weight required, lbs.	Price per lb. s. d.	Cost. s. d.
Cheshire Cheese . .	1·07	0 10	0 11
Bread.	1.77	0 2	0 3½
Milk	8·02	5d. per quart	1 3½
Potatoes	4·43	0 1	0 4½
Apples	6·77	0 1½	0 10¾
Oatmeal	1·05	0 2¾	0 3
Peameal	1·21	0 3¼	0 4
Flour	1·19	0 2¾	0 3½
Rice	1·27	0 4	0 5
Mackerel.	2·89	0 8	1 11¼
Whiting	6·56	1 4	8 9¼
Lean Steak	3·42	1 0	3 5½
Beef Fat.	0·52	0 10	0 5¾
Lean Ham	2·6	1 6	4 1
Butter	0·64	1 6	0 11½
Arrowroot	1·12	1 0	1 1½
White of Egg . . .	8·02	0 6	4 0¼
Isinglass.	1·25	16 0	20 1
Hard-boiled Egg . .	2·07	0 6$\frac{1}{2}$	1 1¼
Carrots	8·78	0 1$\frac{1}{2}$	1 1¼
Cabbage	10·77	0 1	0 10¾
Cocoa Nibs	0·67	1 6	0 11¼
Sugar.	1·15	0 6	0 7
Bass's Ale. . . .	9 bottles	10d. per bot.	7 6 ?
Guinness' Stout . .	6¾ „	10d. „	5 2½ ?

The position occupied by oatmeal as a cheap source of force shows that its extensive use appears thus founded on sound economical principles. Certainly few foods can compete with it in respect to its capability of affording support to the bodily functions at a minimum of expense. The comparative small force-value of animal foods, combined with their high price, render them (according to the foregoing table) most uneconomical articles of diet. It should, however, be remembered, the relative digestibility of the various foods is a

condition of considerable importance, not only on dietetic grounds, but also from purely mechanical considerations. It has been mentioned above that the labour of digestion is itself a considerable source of internal work, though we are ignorant of its amount. It may therefore frequently happen that the ready digestibility of an article of food may more than compensate for its otherwise inferior value as a source of force.

MODERN EXPLOSIVE COMPOUNDS.

NITRO-GLYCERINE, ITS PERILS, AND ITS PROBABLE USES.

THE explosive compounds with which chemistry has furnished us may very conveniently be divided into two classes, only one of which, however, is likely ever to be applied to practical purposes. The explosion produced by compounds belonging to one of these classes is due to the weak affinity which exists between their constituent elements; and the ease with which, therefore, they suddenly and almost spontaneously separate. A liquid or solid being changed instantaneously, and with uncontrollable energy into gases, which occupy many times a larger space than before. Peroxyde of hydrogen ($H_2 O_2$), and perchloride of nitrogen (NCl_3), are striking examples of this class. The former being decomposed with explosive violence, by mere elevation of temperature, into water and oxygen, on account of the very weak affinity of the second atom of oxygen; and the latter, when dry, by the slightest contact, or the least motion, into chlorine and nitrogen.

Bodies belonging to the other class explode from a very different cause; the result produced in their case being nothing more than a very rapid combustion, due to the presence and complete admixture of the combustible and supporter of combustion. The most appropriate illustrations of this class are found in gunpowder, gun-cotton, and nitro-glycerine. That these are well suited for producing a very rapid combustion is evident from their constitution, which is as follows:—

Gunpowder	$KO.NO_5$ S+C
Gun-cotton	$C_{24}H_{17}O_{17}.3NO_5$
Nitro-glycerine.	$C_3H_5O_3.3NO_5$

This formula for gunpowder is what has been found by theory, but it corresponds very nearly with that of the best kinds. The constitution, both of gun-cotton and nitro-

glycerine, is as yet uncertain; but it is most probably very nearly the above. The presence of sulphur in the gunpowder is indispensable; but it is objectionable for many reasons. In war it fouls and corrodes firearms; and in both war and mining it produces noxious gases. And hence, one of the advantages, both of gun-cotton and nitro-glycerine, is that the combination of their elements, during their explosion, gives rise to no corrosive or suffocating compound; nor does either of them leave any residue.

The resemblance between the constitution of these three important bodies is very striking. In all of them nitric acid, which is extremely rich in oxygen, and is very easily decomposed, supplies the supporter. Each of them has, however, its advantages and disadvantages. Gunpowder, for example, is not liable to spontaneous decomposition, but it is spoiled by moisture. Exactly the reverse is the case with nitro-glycerine.

On the present occasion we shall restrict our observations to nitro-glycerine, as it is now exciting considerable attention, and is likely very soon to become, almost exclusively, the explosive agent in mining operations. "Nitro-glycerine," called also "Glonoine," "Nobel's blasting oil," etc., was discovered in 1847 by Sobrero, a pupil of M. Pelouze, who, by acting on glycerine with a mixture of two volumes of sulphuric acid, and one volume nitric acid, and then adding water, obtained a yellowish, oil-like compound, which was inodorous, of a sweetish pungent taste, producing headache, when merely applied to the tongue, and highly explosive. This remarkable compound for a considerable time attracted but little notice. It was long used only as a medicine, and almost exclusively by the homœopathists; and, strange to say, considering its violent properties, was prescribed as a cure for nervous affection.

It is merely a compound of nitric acid and glycerine. The latter, though so energetic in combination, is one of the mildest substances known. It was discovered by Scheele in 1779; and, from its extreme sweetness, was termed by him the "sweet principle of oils," a peculiarity indicated by its present name. It ranks as an alcohol, since its formula may be considered as $\left.\begin{matrix} C_3H_5 \\ H_3 \end{matrix}\right\} O_3$. Combined with the fat acids, it affords, in the fixed oils and fats, compound ethers. In saponification the acid of the compound ether unites with the inorganic base, the glycerine being set free. It forms a great number of compounds, in some of which it is combined unchanged; thus in the case of the fat acids; in others, the monatomic radical acid takes the place of one or more atoms of its hydrogen.

It is produced during the alcoholic fermentation of sugar, and it occurs in all fermented liquors, but particularly in wine. It may be formed artificially with great ease.

When glycerine is acted on by nitric acid alone, and at ordinary temperature, oxalic acid is the result; but when submitted to the action of a mixture of nitric acid and sulphuric acid at a low temperature, three atoms of the nitric acid combine with one atom of the glycerine, nitro-glycerine being formed.

Nitro-glycerine is heavier than water, its specific gravity being 1·6. It is insoluble in water, but dissolves in alcohol and ether. Its insolubility in water renders it extremely valuable for subaquæous purposes. Possibly it may be found well adapted for torpedoes. It freezes at about 46° Fahr., and explodes at about 350°. Flame will not always ignite it; and when it is struck with a hammer on an anvil, only the portion which is actually struck explodes. It is exploded, however, by agitation or friction—when frozen, by the friction even of its own particles; a very serious source of danger, as it freezes at very moderate temperature. Considering its resemblance to gun-cotton, and the circumstances under which it sometimes ignites, there is but too good reason to believe that it is liable to spontaneous decomposition, which might easily give rise to a temperature sufficiently high to cause ignition. It is probable that the oxygen of the nitric acid which it contains slowly combines with its hydrogen and carbon. In such a case, heat would be generated, and, if not allowed to escape, would accumulate to a perilous or even fatal extent. One of the greatest dangers that accompany nitro-glycerine arises from the fact that it can be made only at a low temperature, and that it explodes if the temperature is very moderately augmented. Nevertheless, were it not liable to spontaneous decomposition, it would be at least as safe as gun-cotton. Gun-cotton often explodes from a similar cause. If it is slightly acid, fumes will be generated by the reaction of the acid; and if these fumes are not allowed to escape, and especially if the heat is retained by means of non-conducting bodies, the temperature will become high enough to cause ignition. Such a result is extremely likely to take place if the gun-cotton is placed in a bottle, which is surrounded by sawdust contained in a wooden box. Many explosions that have puzzled photographers are explained in this way; and there is reason to believe that nitro-glycerine in wooden boxes has exploded from similar causes. The composition of nitro-glycerine being so similar to that of gun-cotton, it is not wonderful that it will ignite in similar circumstances.

Nitro-glycerine is supposed to be eight times as powerful

as gunpowder, weight for weight, and thirteen times as powerful, bulk for bulk. This renders it, though dearer than gunpowder, more economical for mining purposes, on account of the diminished labour in boring. It requires no tamping; the hole in which it is placed, and which may without inconvenience be damp, may be merely closed with water or sand. If there are any crevices, they must of course be stopped, or the oil will flow away, and be wasted; but damp clay will answer well for the purpose.

Various experiments have been made, with the object of testing the explosive power of nitro-glycerine, some of them for the purpose of comparing it with gunpowder. Thus a hole fifteen inches deep was bored within eighteen inches of the edge of a large block of calcareous stone; and a charge of oil one and a half inches deep was placed in it, after which it was closed with plastic clay. The explosion caused the block to be blown into small fragments; a similar charge of powder broke a similar block into only three pieces. A hole three feet deep and one and a quarter inches in diameter was bored in a solid rock three feet from its face, and three ounces of nitro-glycerine were placed in it, and covered with a wad of paper, on which water was poured. The explosion caused a displacement to the depth of six feet. In a subsequent experiment the hole, which was eight feet two inches deep, and half an inch in diameter, was bored nine feet from the face of the rock, and was charged with oil to the depth of eighteen inches. The explosion completely separated one hundred tons of the rock. There is reason to believe that half a hundredweight of gunpowder would be required to produce the same effect.

The wonderful capabilities of nitro-glycerine as an explosive agent have been hitherto, unfortunately, far more than counterbalanced by the fearful damage with which its use is accompanied. Already some appalling catastrophes have been produced by it; and the recklessness with which it is carried from place to place, and the temptation there is, from motives of economy, to pass it as ordinary merchandize, greatly enhances the peril; so that a stringent parliamentary enactment regarding it is loudly and somewhat generally demanded. That legislation, to some extent, has become necessary, can scarcely be denied, the destruction of life and property by means of this terrible agent, having been already so considerable. In November, 1865, an explosion of nitro-glycerine occurred in Greenwich Street, New York. It was caused by a quantity contained in a small rudely-formed box, which was found in the baggage-room of the Wyoming Hotel. Red fumes of an offensive smell being observed to issue from the

box, an alarm was excited which led to its being thrown out of the window into the street, where it immediately exploded with great violence. The fumes which were emitted on this occasion point very probably to a cause very similar to that which often gives rise to the explosion of gun-cotton. At Sydney, one hundred pounds weight of nitro-glycerine exploded. On the 3rd of last April, seventy cases of it exploded at Aspinwall, the Atlantic terminus of the railway which crosses the Isthmus of Panama. The "European," a vessel about 1700 tons burden, which contained them, was nearly destroyed; a large ship beside her was greatly injured; the freight house, a fine building, was blown down, and 400 feet of the quay was obliterated. Upwards of seventy persons were killed and wounded on this occasion, and not a single whole pane of glass was left in the city.

The magnitude of the mischief caused by this explosion gives but little idea of the damage which these very cases might have caused. Will it be believed that London, only by the merest good fortune, escaped devastation through them; and not only London, but Liverpool, and several other important towns; for they were transmitted from the place of manufacture with the utmost negligence, as if the most ordinary merchandize: travelling across England from Hull to Liverpool, and across the Atlantic, touching at important places till they reached the locality where they caused such terrible destruction. The horror excited by the explosion of gunpowder at Erith is obliterated by the consideration of what might have happened had the seventy cases of nitro-glycerine which blew up at Aspinwall exploded a little sooner, at London or Liverpool; and that they did not explode, considering the dangerous character of the compound, must be looked upon as little short of a miracle.

Similar casualties have followed in quick succession. On the 16th, also, of last April, an explosion of nitro-glycerine happened at San Francisco, by which many persons were killed, and 200,000 dollars worth of property destroyed. The oil was contained in two boxes, which, to save a comparatively trifling expense, were transmitted through the most important and populous localities in Europe, as ordinary merchandize.

What conclusion is to be drawn from these terrible casualties?—that the manufacture of nitro-glycerine ought to be prevented? Certainly not. Science, which has supplied the bane, will undoubtedly supply the antidote also, if it has not already done so. In the meantime, too much caution cannot be used: but we must not allow ourselves to be carried away by our fears. Both gunpowder and gun-cotton

were, at first, managed with difficulty; and each has contributed its own share to the chapter of accidents. As to gunpowder, with reasonable precautions, notwithstanding the catastrophes to which it has from time to time given rise, it is considered almost free from danger. The history of gun-cotton is a short one, yet it recounts numerous and terrible accidents. In 1847, a quantity of gun-cotton blew up a factory belonging to the Messrs. Hall, and killed every one in the establishment. In 1848, more than 3000 lbs. of it exploded in Paris, reducing the most massive walls to powder. Numberless other accidental explosions of it are on record; yet it is now made everywhere, if not for military or mining purposes, at least for those of the photographer.

Already experiments have been made by Nobel, the Swedish chemist, who first utilized nitro-glycerine by applying it to mining, which go far to prove that it may be made perfectly harmless for the purpose of transport or storage. He has recently ascertained the important fact, that, when methylic alcohol (common wood naphtha), a very cheap material, is dissolved in it, neither heat nor percussion cause it to explode; and that this preservative medium is separated from it with even still more ease than the pulverized glass, etc., which is used to render gunpowder inexplosive. On adding water, which takes up the alcohol, the nitro-glycerine will separate and fall to the bottom; it is then easily obtained, without admixture, by means of a syphon, all its peculiar properties being completely restored. J. W. M'G.

THE PLANET SATURN.

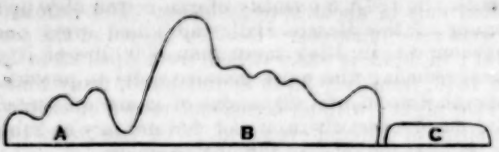
(CONTINUED.)

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

THE conclusion to which the American astronomers were led in 1848, as to the cause of the knots of light upon the ring, has been endorsed in 1861-2 by Secchi, who found that when the dark side of the ring was turned towards us, light still reached us through the great division; and that the ring never entirely disappeared in that position, being traceable as a very slender and feeble line. This, however, he seems disposed to refer, not, like other observers, to its actual thickness, but either to the effect of a refracting atmosphere surrounding it, which he thinks probable from other considerations, or to some degree of transparency.*

* His figure shows the belts entirely disappearing before reaching the limb. 1861, Nov. 5, he saw a dark spot near the centre of the disc: Nov. 15, there was an irregular blackish patch on the ball. He repeatedly noticed the "square-shouldered" form, but only in an inferior air; in fine weather the ellipse was perfect.

Our readers may be interested in seeing a copy of a diagram by this eminent observer, representing by the vertical height of the various parts of a curve above a horizontal line, the proportional brightness, as observed by himself, 1855, Dec. 24, of the corresponding parts of the whole system of rings.



It will be seen that he delineates the light as continuous between A and B, but not between B and C.

The next point to which our attention will be directed will be the *eccentricity of the ring* considered as a whole, or, which of course is the same, the non-concurrence of the centres of figure of the ring and of the ball. This is, perhaps, what we might not have expected; but there is, nevertheless, a considerable balance of evidence in its favour. It was first noticed, as far as we know, in 1664, by Gallet, a priest of Avignon, who, though a fanciful theorist, was probably possessed of an acute sight. He referred it, however, erroneously, to a perspective effect depending upon the position of our eye. It seems then to have been forgotten, till it was independently re-discovered in 1827 by Schuzbe, who remarked that the ball lay W. of the centre of the ring. This was confirmed by Harding and others, and Schumacher, in 1828, and demonstrated micrometrically by Σ I. at Dorpat, who measured it on six evenings with nominal powers of 480 (384) and 600 (400), and found a result (reduced to mean distance) of 0″·215, $= \frac{1}{3\cdot 0}$ of either dark space.* Schwabe subsequently kept it in view during fourteen years, and thought that it was variable in extent. He paid especial attention to it with a 3¼ and 6-ft. achromatic in 1841, and on thirty nights, between July 13 and October 10, found the dark space considerably broader on the

* Herschel and South's 35 measures in 1828 had a negative result; but they gave the dark space only 3″·569, while Σ I. made it 4″·339. H., however, and several others, thought that the E. opening *looked* the larger. The following remarks, by some of the most eminent astronomers, deserve the student's careful attention:—

"It appears to me that when a *comparison* of dimensions sufficiently answers the purpose, greater accuracy is often obtained optically than by the application of the micrometer" (Lassell).

"In this instance" (the conjuction of a satellite) "the eye is more to be depended upon than micrometric measurements" (Bond II).

"A practised eye would fill up and even *correct* the representation drawn from micrometrical measures" (De la Rue).

"The eye may sometimes be trusted more than the micrometer" (Dawes).

E. side; on ten nights much less so, or not perceptibly different. He prosecuted the enquiry at Dessau conjointly with De-Vico, at Rome, and their simultaneous observations agreed very well; but while concurring as to the fact of a variable amount of eccentricity, they could detect no period; the displacement sometimes seeming to reach its extreme amount in two or three, but often only in about seventy hours. The Roman observations were very numerous. De-Vico measured the eccentricity in 1841; in 1842 it was watched from April 23 to November 20; in 1843, from July 24 to September 3, many times in each observing night; with an occasional record of visible changes in the space of 10, and even 5 m.! Of late years this phenomenon has not received a like degree of attention. Smyth never could detect it. Secchi considered in 1855 that it existed, though in a slight degree, and notes that, Dec. 27, it was not perceptible. Bond I., 1852, Nov. 29, measured the E. opening 5″·25, the W. 4″·26, the former also being the larger to the eye: and it appears strange that no further notice is taken of so remarkable a feature. Coolidge, on three occasions in 1857, alludes to some inequality in the "crescents," or innermost dark spaces; but this is equivocal, as it may have been due to a temporary irregularity in the width of the dusky ring. Grover (1866) considers it to be visible, as well as the greater distinctness of Ball's division on the same (E.) side, with even two inches. This may at first appear strange, but it is not contrary to analogy or experience, for it has often been noted that some kinds of minute differences are more perceptible, proportionally at least, when the objects to which they relate approach the inferior limit of visibility.

We may remark that it does not seem to have been borne in mind that some variation in the breadth of one of the sides of ring B, of which instances have been known, may have been occasionally complicated with the observed effect; and should this minute but interesting inquiry ever be seriously taken in hand, it would be desirable that measures of the width of the dark "lunule" should be accompanied by simultaneous ones of that of B; though it must be admitted that a difference in this respect always occurring on the same side of the planet is even more improbable, *à priori*, than a similarly-conditioned eccentricity. But here, in fact, lies the anomaly on any supposition: and Humboldt's remark, that the variation and its unequal amount may be the consequence of oscillations in the centre of gravity of the ring about the geometrical centre of Saturn, loses its value as indicating a possible condition of permanence, when it is remembered that the deviation from concentricity, when it is observed, is always in the same direction.

The student who has had the patience to make his way

through the accumulation of detail which has been brought before him, will have noticed repeated indications of want of symmetry in the separate members of the ring-system. As this is not merely a point of curiosity, but of importance in a final review, a few further notices respecting it may be introduced here.

The first, however, indicates want of stability rather than symmetry. 1855, Dec. 29, Secchi was surprised at the unusual apparent breadth of A, rendering it quite unlike the delineations of Dawes and Lassell—an impresssion which was confirmed by measurement, giving it 2″·788—0″·348 more than the mean of the values of Σ I. and II. and Encke. Then between Jan. 9 and April 3, 1856, he measured the whole bright ansæ repeatedly unequal, *p* having four times and *f* once the advantage, with a mean of 0″·119 in favour of *p*. Mar. 2, he saw A the broader *f*, B the wider *p*. 1857, Jan. 13, Bond II. thought A narrower than usual. And these anomalies are in entire accordance with the experience of De la Rue, who states in 1856 that during the last five or six years that he had been assiduously observing, measuring, and making drawings of Saturn, he had noticed irregularities in the widths of especially the two bright rings, and in the dark division between them: that he had frequently observed the rings wider at one extremity of their minor axes* than accorded with their breadths at their major axes, with a corresponding anomaly in Ball's division; and, moreover, that sometimes the E. ansa of one of the bright rings was wider than the W., and *vice versâ*, by quantities quite appreciable to a practised eye, although difficult to determine exactly by measurement.

It might naturally be presumed that such deviations would produce some corresponding effect during the lateral presentation of the rings, and this we shall find to be the case when we have an opportunity of prosecuting the subject. In the meantime we have much pleasure in laying before our readers the latest and most reliable values of the several parts of the Saturnian system, as deduced with great care by Mr. Hind, and recently published by Mr. Bishop for the convenience of astronomers:—Outer diameter of ring A, 39″·76—inner do. 35″·22—outer do. of B, 34″·26—inner do. 26″·32—inner do. of C, 22″·10. Equator of globe, 17″·56 Breadth of A, 2″·27—do. of Ball's division, 0″·48—do. of B, 3″·97—do. of black space, 2″·27. Ellipticity of globe, 110·018.

* It will be remembered that one of the minor axes of B is always, and of A for long periods together, hidden behind the ball.

ARCHÆOLOGIA.

SOME CURIOUS ANTIQUARIAN REMAINS have recently been discovered in the immediate neighbourhood of Salisbury, consisting of what the explorers name PIT-DWELLINGS. The site of this discovery is a field in the parish of Fisherton, which was accidentally found to be full of ancient pits, occurring singly and in groups. These pits are carried to a depth of from seven to ten feet in the soil, the latter being a drift gravel resting upon chalk. They are nearly all circular, from five to seven feet in diameter, and narrowing at the top from three feet six inches to two feet six inches. The floors were of chalk, some being raised about eight inches in the centre, and shelving off at the sides. "Moveable circular covers appear to have been used for the pits; these were composed of interlaced sticks coated with clay imperfectly burnt." It is further stated that the entrance to each pit, or to each set of pits, are nearly all circular descending shafts. We take our account of these remains from a communication to the *Wiltshire County Mirror*, of the 20th of June, by Mr. E. T. Stevens, of the Blackmore Museum, Salisbury. Mr. Stevens's description, though on the whole very satisfactory, seems, we think, a little deficient in one or two circumstances; he does not inform us if any portions of the circular covers of wicker-work have been preserved, or if they are merely conjectural; nor has he explained how the pit was entered from the descending shaft, or what kind of communication existed between the pits, when one shaft served for a set of pits. He tells us that the most interesting group of pits was the one first opened. "It consisted of three circles and a semicircle, all communicating with each other, there being but one shaft-like entrance on the northern side. In the largest pit of this group (seven feet in diameter), on the floor, and at the northern side, were found the most important specimens hitherto obtained."

These specimens, as far as present discoveries go, appear to be of no important or very decisive character. They consist, in the first place, of fragments of rude pottery, not made on the wheel, but displaying "a considerable amount of skill in decoration and in colouring." It is evident that we can only judge of this pottery when we have it under our eyes; but the colouring, especially, seems to us to imply that it is hardly of the extreme antiquity which seems to be claimed for it. We must be cautious in taking mere rudeness of make for evidence of antiquity. Among the other manufactured objects found in the pits, are a bone needle with a drilled eye, two combs with short, thick teeth, and a long handle for grasping, drilled at the end as if for suspension, and one of them ornamented with zigzag lines. One is of bone, and the other made of the antler of the red deer. Mr. Stevens remarks the striking deficiency of objects in worked flint, all hitherto found being a solitary leaf-shaped arrow-head, and one hatchet (unrubbed). No trace of metal of any kind has yet been found, but the mere absence of metal must not be regarded as a proof that the other objects

belonged to a "stone-age," or we should find plenty of articles, modern enough, laying claim to this character. We learn further that there have been found in the pits at Fisherton two or three concave stone grain-rubbers (querns), of a very simple type, a spindle-whorl of burnt clay, with two dressed and drilled lumps of chalk, which exhibit traces of considerable wear at the drilled hole, evidently from having served as weights. Among the animal remains are enumerated those of a small race of horses (which predominate), a skull, as well as numerous bones and teeth, of the *Bos Longifrons*, and remains of the red deer, a small variety of goat, the sheep, dog (or wolf), pig, water-rat, field-mouse, house-mouse, toad, frog, and fish. Nearly all the bones are scored, as if with flint-knives, especially in the parts where the sinews were attached, and some of them bear marks of having been exposed to the fire.

These discoveries, as described by Mr. Stevens, are very interesting; and we are glad to hear from him that the excavations are to be continued. At the same time, we can hardly bring our mind to the belief that they are dwellings at all. Nothing yet discovered in them seems to us to intimate that they had been used as habitations; and we can hardly understand people living in pits from seven to ten feet deep, by five, or rather more, in diameter. If, as is conjectured, these pits were the winter dwellings of the early inhabitants of this district, we must conclude that the latter were in the habit of condemning themselves during the winter to solitary confinement, and that, too, without fires, as there are, we think, no traces of fires at the bottoms of the pits, nor could there be room for it. All this, we know, is quite contrary to the habits of the rude peoples of our colder climates, who have always sought to group themselves together and pass the long winter nights with gambling or other amusements. With the little we yet know of them, it would be difficult to conjecture the real purpose of these pits; but it is possible that they may bear some analogy to the equally mysterious pits, though of larger dimensions, which are found in the chalk hills of northern and central Kent. The latter were long supposed to be magazines or a sort of store-rooms; and it has been conjectured that they were burial places, but this may admit of a doubt.

Since writing the above we have received, through the kindness of Mr. Stevens, outline sketches of the objects found in the Fisherton pits. The two bone combs are perfectly identical in character with the one found in Thor's Cave, described below, and may have belonged to the latter half of the Roman period, while the pottery, as far as we can venture to give an opinion without seeing the fragments themselves, appears to us to be late Roman or perhaps even Anglo-Saxon.

Considerable interest has been excited among antiquaries by researches which have been pursued in Thor's Cave, in Derbyshire, until the close of the autumn of last year. It is hardly necessary to state, that all these caves containing the remains or works of man have attracted great attention during late years, on account of their supposed bearing on the question of the great antiquity of

man, although the objects hitherto found in them present no marks of a very remote antiquity. It is evident that most of them were occupied by man during at least a considerable part (the later part) of the Roman period, and during the period which followed the overthrow of the Western Empire. Thor's Cave is situated in a romantic position in a precipitous rock, which rises from the banks of the river Manifold, in Wetton Dale, near Dove Dale. Some modern local etymologists seem to think that the name is a mere transposition and corruption of "the cave in the Tor;" but we look upon this as by no means a probable derivation; various names by which it has been known, such as Thor's Cave, Thor's House, Hobhurst Cave, Thurshole, and Thyrsis Cavern—the latter given by Dr. Plot—with scraps of legends connected with it, lead us to believe that the name, whatever it may really be, has arisen out of some superstitious feeling with which the place has been regarded. Thyrse's, or Thurse's cave would mean "the cave of the spectre;" and we are told that one of the above names belongs to a very old tradition, that it was formerly the retreat of a very mysterious being, called Hobhurst, a sort of Robin Goodfellow. All these legends seem to point to its having been the habitation of man (probably late) in the middle ages. We may add, that Thor's Cave extends internally in the heart of the rock to a very considerable extent, and that it presents two external openings, or entrances, the principal, and much the largest, on the northern side; the other on the western side of the rock.

A very interesting account of the exploration carried on in the cave last year is given in a recent number of the *Reliquary*, with a list of the objects found in it, accompanied with a considerable number of good illustrative engravings. Most of the pottery, of which the fragments were numerous, found in this cave, is decidedly Roman in character; it includes several pieces of Samian ware. The only object coming under the title of "stone implements" was a smoothed instrument of green stone, which the writer of the paper to which we refer thinks may have been used in flaying animals. There were found two fragments of querns, whetstones of grit, and a small perforated disc of sandstone, of the class considered to belong to spindle-whorls. The objects made of bone were more numerous, and among them were no less than seven examples of an implement formed of the snag of a deer's horn, and cut and perforated in a manner which might lead to the supposition that they were intended for whistles. It has been conjectured that they may have been used for fastening wearing apparel—perhaps by people of a class who could not afford to buy fastenings of metal.

Among other objects formed of bone were a rather curiously shaped comb and a pin. The objects made of iron, which were tolerably numerous, were mostly unmistakably Roman. They consisted of arrow and lance heads, and of other cutting and hammering implements, one or two of which perhaps belong to the Anglo-Saxon period, of pins of various sizes, several supposed mining tools, a broken reaping-hook, and a variety of other articles of which it would be difficult to fix the exact use. There was also a rather

singular object, considered to be a spindle-whorl, of lead, of the shape of a half sphere, pierced through the centre, and ornamented on the flat face with two concentric grooves. The objects made of bronze and copper were less numerous, and consisted chiefly of ornaments for the dress or person, such as an hoop-shaped bracelet, several fibulæ and ringed pins, plain pins, and a few other articles. The only coin was one in second brass of the Emperor Hadrian. The writer of the description printed in the *Reliquary* ascribes these objects to "the late Celtic, the Romano-British, and the Anglo-Saxon periods." We see no article among them which presents the slightest traces of Celtic character, or which implies necessarily an earlier date than the middle of the Roman period. It is curious, in this respect, how uniformly the contents of these caves point to one period as that during which they were inhabited—rather late Roman and perhaps rather early (though not necessarily so) Anglo-Saxon. They show us how imperfectly we are acquainted with the condition of a large part of the population of our island during the Roman and earlier Saxon periods, and how cautious we ought to be in forming opinions on any subject connected with it.

A Roman INSCRIBED SEPULCHRAL MONUMENT has recently been discovered at Lincoln, in a part of the town called Salt House Lane, which lay outside the walls of the Roman town, by the side of the Roman road, and formed one of the cemeteries of ancient Lindum. The inscription indicates that it stood over the grave of a Roman soldier of the ninth legion, who was forty years of age, and had served twenty-two years. The inscription runs as follows:—

C SAVFEIO
C· F· FAB·HER·
MILIT LEGIO
VIIII
AN·XXXX
H·S·E·

Which may be read, "*Caio Saufeio, Caii filio, Fabio Herennio, militi legionis nonæ, annorum xxxx., stipendiorum xxii. Hic situs est.*" This inscription belongs probably to an early period in the Roman occupation of Britain, as the ninth legion disappears from history after the wars under Agricola, and, as it is mentioned in inscriptions found at York (*Æburacum*), it has been supposed to have been incorporated, for some reason or other, with the sixth legion, which was stationed there.

Mr. John Brent, Jun., of Canterbury, whose recent discoveries at Sarre and other localities in East Kent have excited general interest, has just discovered and opened eighteen graves in an ANGLO-SAXON CEMETERY, on the property of the Marquis of Conyngham, at Patrixbourne, near Canterbury. This cemetery, the existence of which was previously unknown, appears to be of considerable extent. The contents consisted of swords, spear-heads, umbos and braces of shields, knives, buckles, fibulæ, some of the latter set with garnets, rings, various ornaments of the person and dress, and a variety of other interesting objects. It is very desirable that this cemetery should be further explored.

An account of the antiquities found in the PEAT MOSSES OF SLESVIG, from the Danish of Conrad Engelhardt, has just appeared in a handsome 4to volume, under the title of *Denmark in the Early Iron Age.* The Danish antiquaries are not satisfied with an "iron age," but they now divide even that into three parts, "early," "middle," and "transition." On the very unsafe evidence of some Roman coins, the antiquities described in this volume are ascribed to the third century after Christ, which is the date given to the earliest of these three divisions, whereas, any one well acquainted with Anglo-Saxon and early Frankish and German antiquities, must recognize them at once as belonging to a period not earlier than the fifth or sixth century. In fact, they are exactly of the same class as those found in our Anglo-Saxon cemeteries, and consist of a mixture of Roman, sometimes considerably debased, and Teutonic. Those described in the present volume were taken from the peat mosses of Thorsbjerg and Nydam, in South Jutland or Slesvig, which are supposed to have been formerly sacred lakes, and the most plausible explanation of the presence of these objects in those localities is that they were offerings to the gods to whom the lakes were consecrated. This seems to be confirmed by the circumstance that they were found in groups, and that three boats, of which one at least of great dimensions, which were found in a remarkable state of preservation, had evidently been sunk with the objects they contained, by design. Perhaps the warrior chief, when he had returned from his raid into the Roman province at the decline of the Roman power, laden with plunder, gave a portion of it to his gods, by sinking it in the sacred lake. The old Scandinavian boats are especially remarkable, and the details here given of them are well worthy of study. Some of the swords have the name of the maker stamped on the blade, and it is singular that these are given in Roman letters, and in exactly the same formulæ as the potters' names on the Roman Samian ware. Thus we have on one ....ICCI·M. (the first part of the name is erased), *i. e.*, ...*icci manu;* and on another COCILLVS, with the F, which followed it, erased, for *Cocillus fecit.* Singularly enough, the name Cocillus, or Coccillus, occurs not unfrequently with the same combination, on the Samian ware. There were found with these antiquities a complete tunic, a pair of hose or trowsers, and other portions of dress. These objects are, however, so numerous, and so varied, that it would be impossible to give any notion of them within the compass of a few lines, and we must refer the reader to the well-executed plates with which this volume is illustrated.

T. W.

LITERARY NOTICES.

THE HARMONIES OF NATURE; OR, THE UNITY OF CREATION. By DR. G. HARTWIG, author of the "Sea and its Living Wonders," and "The Tropical World." With numerous Woodcuts. (Longmans.) —There is no doubt that a handsome, richly illustrated volume like this of Dr. Hartwig, roaming from the "starry heavens" to the "majesty of the ocean," the "leaves of plants," and discoursing of

animals and insects of various sorts, will be attractive to a great body of readers, and not the less so because the literary or scientific critic will discover some faults. The style is too flowery and stilted to deserve commendation, and the philosophy is often presumptuous and shallow; but decided cleverness is shown in the selection of topics, and in sustaining a mode of treatment that is well adapted to secure popular interest. Books of this class, though not strictly scientific, act as recruiting sergeants, and bring it large bodies of volunteers. They ought, therefore, to be encouraged, and especially so, when, as in the present case, the illustrations possess far more than average merit both for beauty and accuracy.

ELEMENTARY TREATISE ON PHYSICS, EXPERIMENTAL AND APPLIED; FOR THE USE OF COLLEGES AND SCHOOLS. Translated and Edited from Ganot's "Elements de Physique" (with the Author's sanction), by E. ATKINSON, Ph. D., F.C.S., Professor of Experimental Science, Royal Military College, Sandhurst. Second Editon, revised and enlarged. Illustrated by a Coloured Plate, and nearly 700 Woodcuts. (Baillière.)—Mr. Ganot's work has been long recognized as by far the best text-book on physics; but the progress of scientific discovery required that it should be re-edited, and brought down to date. The present edition differs from Mr. Atkinson's former translation chiefly in additional matter of this description, and we notice a considerable and highly valuable extension of information on the subject of heat. It would have been advisable to have made similar additions to the sections on the spectroscope, which are still left too imperfect. If this book were new, we should devote several pages to explaining its method, and commending its plan and style; but as in its former edition it acquired a very high and well-deserved reputation, we have only to say that Professor Atkinson's labours, as shown in this second edition, will be found to maintain its reputation as by far the best work of the kind for schools, colleges, and private students. Mr. Atkinson will observe that he has omitted to make the necessary correction in the figures representing the velocity of light, and it would have been well to take some notice of the arguments for regarding green as a simple colour.

HANDBOOK OF NATURAL PHILOSOPHY. By DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. Electricity, Magnetism, and Acoustics. Seventh Thousand. Revised and Edited by GEORGE CAREY FOSTER, B.A., F.C.S., Professor of Experimental Physics in University College, London. With 400 Illustrations. (Walton and Maberly.)—Looking to the present state of experimental science, we cannot say that this is a satisfactory book, nor do we see that any re-editing of Dr. Lardner's once popular treatise could be made so. Since the time of Dr. Lardner's originally composing this manual, the conditions of electrical science have materially changed, and the relative importance of various pieces of apparatus, and of different modes of demonstration, have greatly altered. If Professor Foster had proposed to himself the task of preparing a serviceable manual best adapted to the present wants, he certainly would not have attempted to achieve this purpose by a new edition of Dr. Lardner. In dealing with electricity of tension he would

have given in his treatise the same predominance to coil machines over frictional apparatus, and to experiments connected therewith, that they actually have in experimental laboratories and lecture-rooms; and in other portions of the work an arrangement and method quite different from that of Lardner's would have been adopted. No doubt the present work contains a great deal of important information, but in the course of nature Lardner's book would have died through efflux of time, and no editorial galvanizing can bring it up to the mark of the educational books usually issued by Messrs. Walton and Maberly.

RAIN AND RIVERS; OR, HUTTON AND PLAYFAIR AGAINST LYELL AND ALL COMERS. By COLONEL GEORGE GREENWOOD. Second Edition. (Longmans.)—If we understand Colonel Greenwood's object, it is to contend that marine currents have had nothing to do with hollowing out any submerged tract, so as to produce a configuration of hill and valley, and, in fact, make a valley, which subaerial influence might deepen and modify after the formation had been elevated above the water level. Neither Lyell nor any other geologist that we ever heard of doubted or denied the subaerial influence of running water in excavating channels and modifying surfaces; but the accumulated effects of rain operating through long ages may be often underrated in particular cases.

A LITTLE BOOK ABOUT LEARNING THE PIANOFORTE. Written and compiled by EMANUEL AGUILAR. (Groombridge and Sons.)—Mr. Aguilar tells us that "this little book is intended as a guide and reference to those who, by place of abode and other circumstances, are debarred from the advantage of efficient and regular instruction, but is not designed as a means of self-instruction to these altogether ignorant of the art, nor to supersede the necessity of the assistance of teachers." The first chapter of the book contains well-selected rules and remarks by great composers and players; and the second, which is addressed specially to teachers, is entitled "When and how to commence learning the Pianoforte." The *when* Mr. Aguilar answers by saying that "when a child knows black from white, can distinguish the right hand from the left, knows the alphabet, and can count to seven," he may commence the study. It must not, however, be supposed that so able a musician as Mr. Aguilar contemplates anything like cruelty to infants, in forcing either their fingers or their minds. His early lessons are perfectly easy, and would amuse the young children for whom they are designed, as well as lay a foundation for flexibility and precision in using their fingers. Other chapters describe the mode of giving more advanced lessons, and we should say the work is admirably adapted to assist ladies in instructing their children, and helping governesses into judicious methods. Much misery to young people, and ultimate inaptitude for decent playing, is the result of bungling instruction, and many persons who can play with considerable proficiency do not know how to teach. With Mr. Aguilar's help, any one who can play correctly may learn how to adopt a good method of elementary teaching, and his inexpensive work, which presents a very elegant appearance, will, no doubt, prove of extensive use.

PROCEEDINGS OF LEARNED SOCIETIES.*

GEOLOGICAL SOCIETY.—*May* 23.

The following communications were read:—

"Notes on the Geology of Mount Sinai." By the Rev. F. W. Holland. The physical features of the peninsula were described as exhibiting in the north an extensive table-land of limestone of Cretaceous age, supported and enclosed on the south by a long range of mountains composed of syenite, porphyries, and schistose rocks. Near Jebel Serbal is a mountain of Nummulitic limestone; and a limestone, apparently of more recent date, occurs near Tor and Ras Mohammed. The author further stated that, in some parts of the peninsula the syenitic mountains are capped by horizontal beds of sandstone of considerable thickness, which are unaltered at their contact with the syenite. This sandstone formed the great mining district of the Egyptians in Sinai, and is now worked for *turquoises*, which appear to occur more or less in veins. Raised beaches were discovered by the author on the western side of the peninsula, at elevations of from twenty to thirty feet.

"On a New Genus of Phyllopodous Crustacea from the Moffat Shales (Lower Silurian) Dumfriesshire." By Henry Woodward, Esq., F.G.S., F.Z.S. The fossil described consists of the disk-shaped shield, or carapace, of an Apus-like Crustacean, the nearest known form to it being *Peltocaris aptychoides*, Salter, from which, however, it is at once distinguished by the absence of a dorsal furrow. A line of suture divides the wedge-shaped rostral portion of the shield from the rest of the carapace, the two parts being seldom found together. From their strong resemblance to *Discina*, the author proposed for them the generic name *Discinocaris*, and named the species *Browniana*, after Mr. D. J. Brown, who first drew his attention to it.

"On the oldest known British Crab *Protocarcinus longipes*, (Bell, MS.) from the Forest Marble of Malmesbury, Wilts." By Henry Woodward, Esq., F.G.S., F.Z.S. The author stated that three genera and twenty-five species of Brachyurous Crustacea had already been described by Prof. Reuss and H. Von Meyer from the Upper White Jura of Germany; but as no limbs or abdominal segments had been met with, it was more doubtful where to place them than the species now described, which had nearly all its limbs *in situ*, and a portion of the abdomen united to it. *Protocarcinus* closely resembled the common spider-crabs—the *Maidæ* and *Leptopodidæ* living on our own coasts.

ZOOLOGICAL SOCIETY OF LONDON.—*June* 12.

A communication was read from Dr. H. Dohrn, Corresponding Member, on The Birds of Prince's Island, in the Bight of Benin.

* Matters recently brought before the Royal and Astronomical Societies will be amongst the "Notes and Memoranda."

The species enumerated were thirty-four in number, amongst which were several new to science.

A communication was read from Mr. Jonathan Couch, of Polperro, Cornwall, giving an account of the occurrence of *Ausonia Cuvieri*, a fish new to the British Fauna, on the coast of that county. Dr. Günther contributed some notes on the anatomy of the same fish, which presented several very noticeable peculiarities.

Dr. Murie read some supplementary notes on the Red-bellied Monkey (*Cercopithecus erythrogaster*), a new species founded by Dr. Gray upon an animal lately living in the Society's Menagerie.

Mr. A. D. Bartlett made some remarks on the singular bird of prey lately transmitted from Damaraland by Mr. Andersson, and described by Mr. Gurney as *Stringonyx Anderssoni*, and suggested its identity with the *Machaerhamphus alcinus*, described some years previously by Mr. Westerman, but stated, probably erroneously, by the latter author to have been received from Malacca.

NOTES AND MEMORANDA.

African Elephants.—Two small but very interesting specimens of the African elephant may now be seen in the Zoological Gardens, Regent's Park. The formation of their enormous ears is very striking. Nearly meeting at the back of the neck, and hanging down close to the shoulders, they look like a close-fitting cape through which the head protrudes. The animals appear very good-tempered, and are very willing to make friends with the visitors.

Spores of Horsetails.—From this time till the autumn the horsetails, or equisetaceæ will be conspicuous ornaments of damp situations, and their spores are amongst the most interesting of microscopic objects. If a ripe head of a fertile horsetail is gently shaken over a sheet of white paper, a number of minute green bodies will be seen to fall. These should be transferred to a glass slide, and examined with a magnifying power of fifty or sixty linear, when it will be perceived that each spore is provided with four filaments expanded at the ends. If quite fresh, these filaments will probably be in motion. By breathing upon them they contract close round the spores, and if watched for a few seconds, they will be seen to dart out again vigorously as the moisture which induced their contraction evaporates.

Huggins on Sun Granules.—Mr. Huggins prefers "granules" to other designations of the bodies which have been compared to "willow leaves," "rice grains," etc., because it assumes nothing as to their exact form or precise character. In parts of the sun free from disturbing currents, Mr. Huggins finds these bodies look like rice grains under powers of about 100; but with greater magnification the apparent regularity of their size and shape disappears to a great extent. Many were round, but others are irregular, and they are, as a rule, bounded by broken outlines. Could they be seen more closely, Mr. Huggins believes they would be as "wildly rugged" as our clouds. In size they are about 1" in diameter when round, and about 1".5 when oval. Many were found less than 1", and some as much as 2" or 3". Mr. Huggins gives, in *Monthly Notices*, a very curious sketch of the patterns formed by groups of these bodies. In one case three rows are arranged in a long oval, a little constricted in the middle, the centre being occupied by other granules more thinly scattered. He supposes the granules to be "recently condensed incandescent clouds; that they slowly sink, merge into each other, become less and less luminous, and gradually dissipate into comparatively non-luminous gas." The dark pores, according to this theory, are spots where complete evaporization has taken place.

CHACORNAC ON THE MOON.—We are indebted to M. Chacornac for a paper on the moon, and for a "Notice sur la Constitution Physique du Soleil." The consideration of the latter we must postpone. The former details an important discovery arrived at by the use of a powerful telescope, and a polariscope eye-piece. He finds that certain spots in the moon which correspond in tint and in luminosity under direct illumination, differ considerably under oblique illumination. This indicates a difference in the roughness of the surfaces in question, and in the proportion of polarized light which we receive from them. M. Chacornac speaks of the light rays from lunar craters as indicating "pulverulent ejections," and supposes, from the distances to which they have been thrown, that the eruptions occurred *in vacuo*. He is also of opinion that the surface of the moon bears traces of former tidal action, and degradation of crater walls, etc., by such means. He finds traces of tidal action higher than the present seas, and specially signalized the crater Julius Cæsar, demolished on its northern side, as exemplifying its force.

MAREY ON MUSCULAR CONTRACTION.—Mr. Marey has invented an instrument on the plan of his sphygmograph, which he calls a *myograph*, and which makes a drawing to indicate the movements of muscular fibres in their contractions. A muscular shock (*secousse musculaire*) imparts a wave motion to the fibres. If a shock is prolonged till the muscle is fatigued, the waves lose their amplitude, and finally become extinct. A slow succession of shocks is marked by long ascending lines and short descending ones; a quick succession leads to equality in the ascending and descending lines; and when the shocks are too quick for healthy action—more than thirty-two per second—a tetanic condition supervenes, and a straight line replaces the waved line

NEW MAMMAL FROM CHINA.—A French missionary, M. Armand David, having sent home skins, etc., of the mi-lou, or sseu-pou-siang, a large sort of stag, M. Alp. Milne Edwards describes it to the French Academy. The second Chinese name we have given means "the four discordant characters," the creature resembling a stag in its horns, a cow in its feet, a camel in its neck, and an ass in its tail! The horns, which belong only to the male, are large and branched, but differ in some important particulars to the antlers of the stag. The fur is rough and grey, with a black line on the back and breast. The tail, instead of being short and thick, as is common with stags, is very long, and terminates in a tuft of long hair. The mi-lou is as big as a large stag. Herds of them live in an imperial park some distance from Pekin, but the Chinese do not know where they came from, or on what date they first arrived. M. David thinks that Huc and Gabet spoke of the mi-lou in describing "rein-deer" which they saw beyond Koukou-noor, about lat. 36°. M. Milne Edwards proposes to call the creature *Elaphurus Davidionis*.

MR. HUGGINS ON THE "NEW STAR" IN CORONÆ.—In our last number we gave an account of the spectroscope discoveries made by Mr. Huggins in his examination of the so-called "new star." In a paper in the *Proceedings of the Royal Society*, he says, the appearances "suggest the rather bold speculation, that in consequence of some vast convulsion taking place in this object, large quantities of gas have been evolved from it, that the hydrogen present is burning by combination with some other element, and furnishes the light represented by the bright lines: also that the flaming gas has heated to vivid incandescence the solid matter of the photosphere. As the hydrogen becomes exhausted, all the phenomena diminish in intensity, and the star rapidly wanes. In connection with this star, the observations which we made upon the spectra of α Orionis and β Pegasi, that they contain no absorption lines of hydrogen, appear to have some new interest. The spectra of these stars agree in their general character with the absorption spectrum of the new star. The whole class of white stars are distinguished by having hydrogen lines of extraordinary force. . . . The spectra of several of the more remarkable of the variable stars, namely, those distinguished by an orange or ruddy tint, possess a close general accordance with those of α Orionis β Pegasi, and the absorption spectrum of the remarkable object described in this paper."

ANIMAL ELECTRICITY.—Dr. C. B. Radcliffe describes, in the *Proceedings of the Royal Society*, his success in obtaining indications of statical electricity from living blood, nerve tissue, and muscular fibre, by the employment of gold leaf electroscopes.

REPRODUCTION OF APHIDES.—M. Balbiani, in *Comptes Rendus*, contends that the aphides or plant lice are, as Leeuwenœk supposed, hermaphroditic, while they are viviparous; and he promises in another paper to show how they pass into the oviparous condition. Male and female elements are, he affirms, developed from certain ovules, which he describes. The subject requires the aid of good drawings for its elucidation, and none are given.

A HUNGER-SUSPENDING PLANT.—The power of the *Erythroxylon coca*, of Peru, to suspend the ordinary demand for food, and enable considerable exertion to be undertaken in its absence, has been long known. M. Rossi writes to the *Correspondenza Scientifica in Roma* a letter which, *Cosmos* says, undertakes to show how men may live in robust health for several days without food. M. Rossi describes his own experience, and it appears that, after taking a decoction of the leaves of the plant, no hunger nor thirst is felt for forty-eight hours.

PROF. J. CLARK ON THE "TRICHODINA PEDICULARIS."—The well-known animalculæ so often found running about fresh-water polypi, is the subject of a paper by Prof. James Clark, which will be found in the *Annals of Natural History*. He affirms that the drawings of Ehrenberg, Dujardin, etc., represent the creature in an abnormal condition; but the drawings he gives differ considerably from the usual appearance of the creature as seen in this country. He says, "it has a deep cyathiform, or dice-box shape, with an irregularly and longitudinally furrowed splicated exterior. There is no *disk*, or it is represented by the depressed cupuliform area, which is bordered by the vibratory crown. The *peristome* is not a closed circle, as in vorticellidæ proper, but follows the spiral course of the vibratory crown, and vanishes near the aperture of the vestibule. The vibratory crown consists of a single row of vibrating cilia, which winds along the margin of the spiral dexiotropic peristome just at the edge of the cupuliform disk, and descends thence to the left of the vestibulator aperture, and entering it, plunges to the bottom of the vestibule in an unbroken line." The vestibular lash or bristle, described by some authors he calls an optical illusion. "The so-called adherent organ consists of a distinct separable annular border, whose opposite faces are dissimilarly striated by perfectly straight transverse ridges; secondly, of a complicated circle of disseverable hooks, which are applied to the posterior face of the striated annular border along its proximate edge; and thirdly, of a series of Γ shaped radii, which lie one by one opposite the several hooks, and converge towards the axis of the basal plane of the body. The vestibule and œsophagus are un-marked. . . . The vestibule opens near the cilia-crowned margin of the sunken cupuliform disk. The anus opens into the vestibule, a short distance from the mouth. The contractile vesicle performs its systole once in fifteen seconds. The reproductive organ is a knotted band, and lies in the form of a crescent near the base, and transverse to the longitudinal axis of the body."

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